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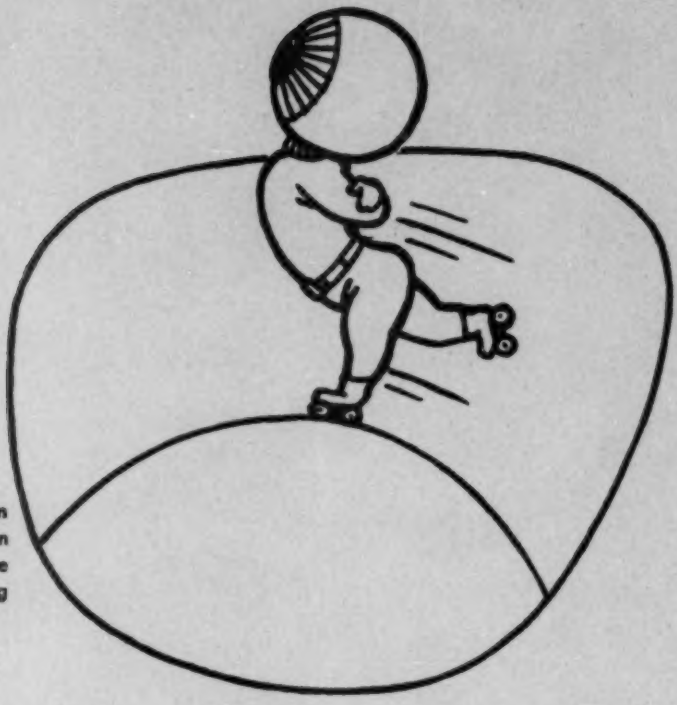

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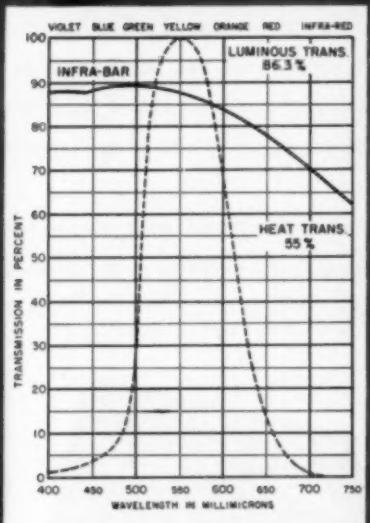

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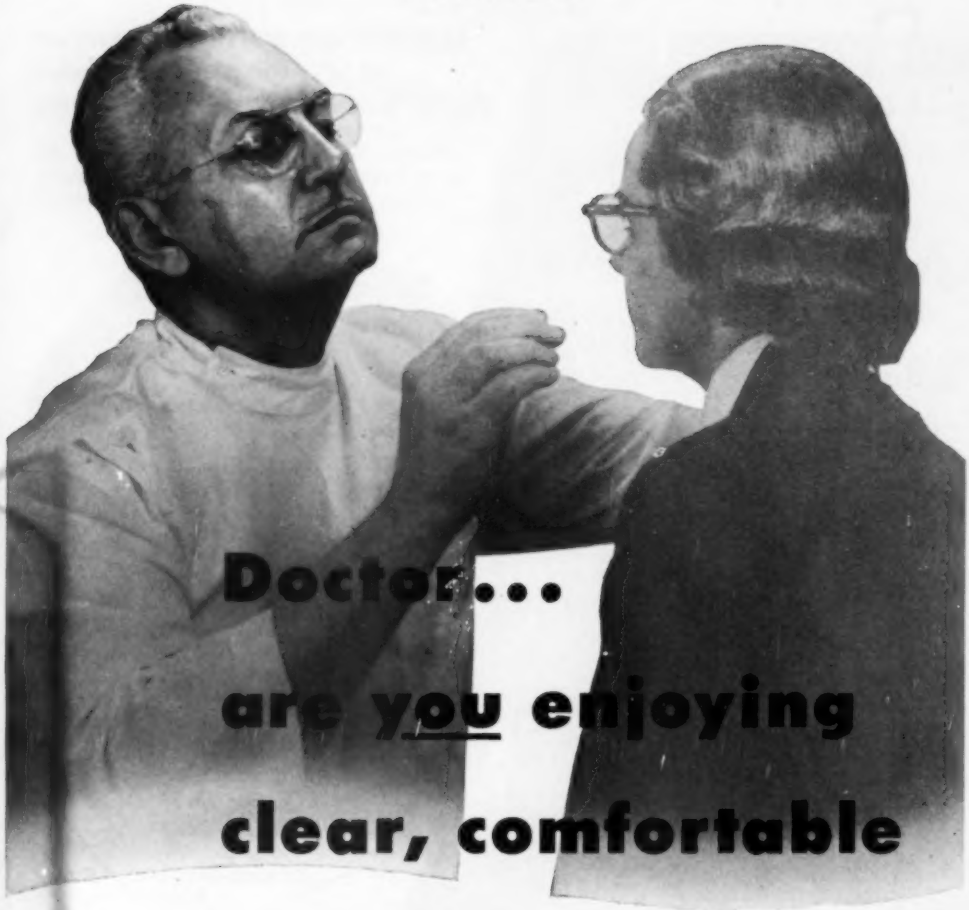

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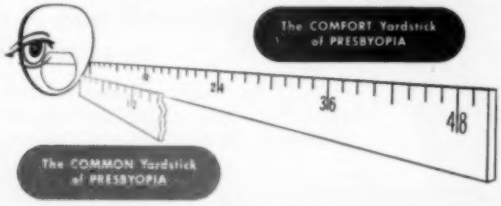

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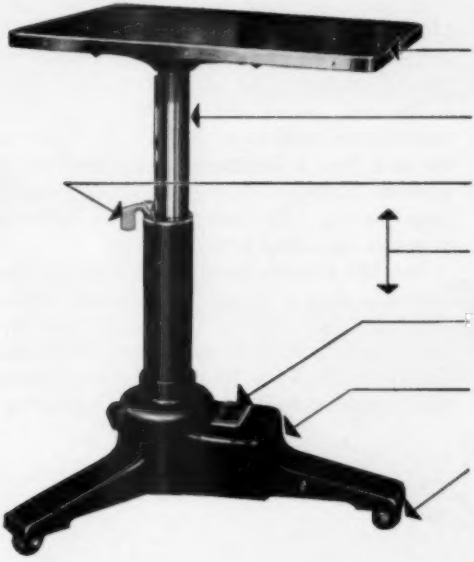

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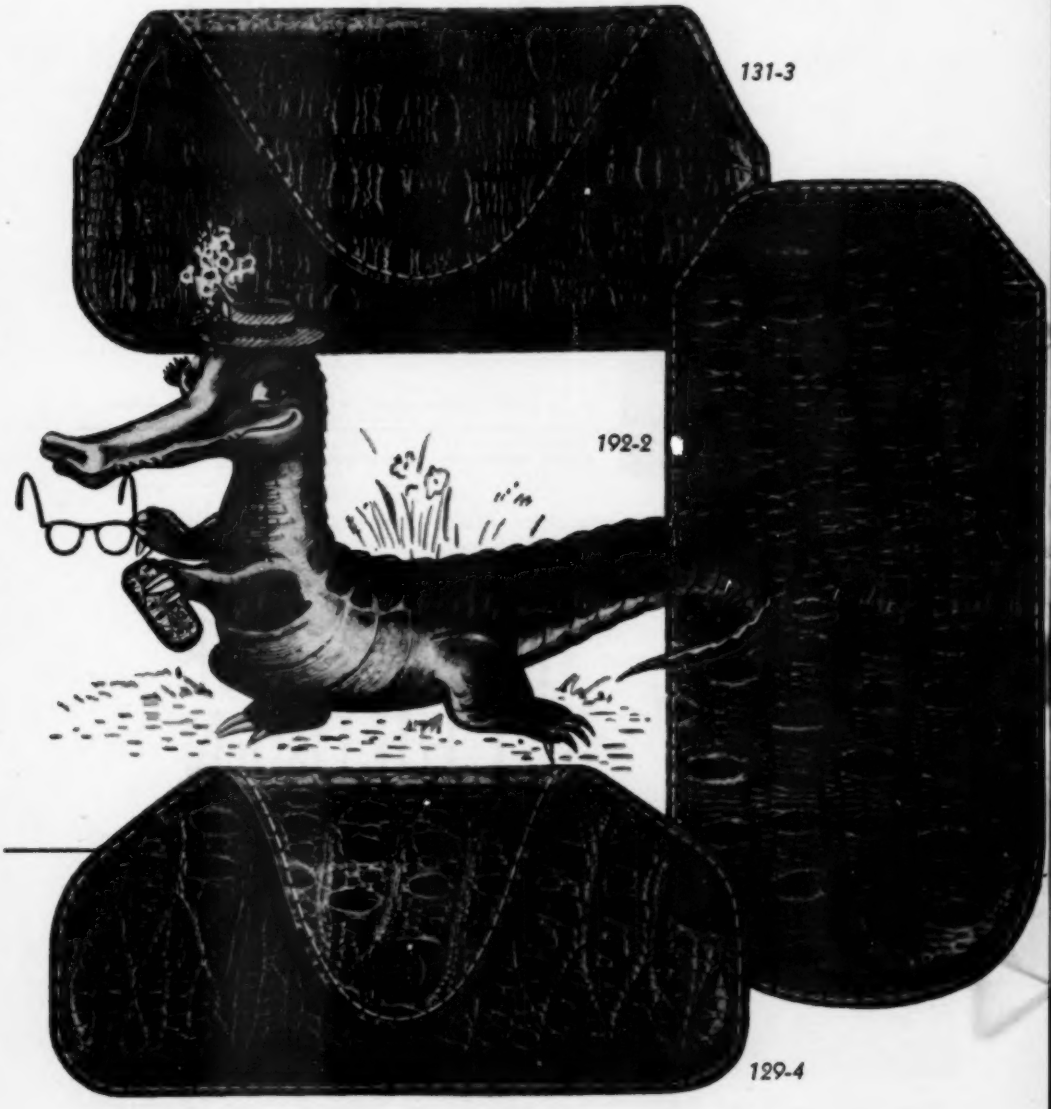

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CHANGES IN ASTIGMATISM ASSOCIATED WITH THE DEVELOPMENT OF CATARACT*

William M. Lyle†
Winnipeg, Manitoba, Canada

Experienced refractionists have stated that the astigmatic correction required by an eye in which cataract was developing differed in either amount or axis or both from what would be expected in a normal eye. The irregular scissor-like movement of the reflex observed in retinoscopy of cataractous eyes is believed to be due to the unequal refractive power of different sectors of the lens.[8] The total astigmatic error of the eye is largely the resultant of the combination of the corneal astigmatism with the lenticular astigmatism. It therefore seems probable that the lens changes associated with the development of cataract alter the total astigmatic error of the eye.

Duke-Elder[12] states "Irregular lenticular astigmatism is usually refractive and is most commonly seen during the maturation of cataract, owing to regional differences of refraction."

Duke-Elder[13] (using the term "inverse" where we usually say "against-the-rule") further says, "The evidence is that such astigmatic effects are small and are usually inverse in type: but in the normal sclerosis of age they may become clinically obvious and may be accentuated to produce extreme distortion or even polyopia in the grosser changes of cataract."

Norris and Oliver[22] state "Patients require the correction of some small astigmatism produced by the unequal swelling of the lens."

Norris and Oliver[23] further state "We often find that a reversal of the normal astigmatism has occurred and that the horizontal meridian has acquired the highest refraction."

Schuler[25] says "The cornea shows astigmatism of one kind and retinoscopy and subjective tests reveal astigmatism of the opposite kind."

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†Optometrist. Fellow, American Academy of Optometry.

Beau-Seigneur[1] says "Changes in astigmatism may result from lenticular astigmatism caused by irregular density of a particular portion of the lens, for example a small cataract."

Gifford[19] says "Cuneiform opacities produce astigmatism at irregular axes."

Wolfe[30] has found that developing cataract may produce a rapid increase in against-the-rule astigmatism.

Fuchs[17] lists unequal refractivity in different portions of the lens as a precursor of cataract.

Borish[4] and many others[28] include incipient cataract as a possible cause of altered lenticular astigmatism. Few go as far as Reinitz[24] who says "In case of cataract of any degree the ophthalmometer reading loses its usefulness and importance to the point where it should be ignored in favor of other findings."

Wheelock[31] concludes that "evidence thus far presented is sufficiently conclusive to discourage the notion that against-the-rule astigmatism is to be found in all cataract cases." Seventeen per cent of his cases showed such a change but 57 per cent remained free from astigmatism.

The purpose of this paper is to report the results of a survey of 327 cataractous eyes, with special references to the changes in astigmatism in these eyes.

DEFINITION OF CATARACT

It is well known that small lens or capsule opacities can be found in the eyes of almost all adults. This is particularly true if the biomicroscope and slit lamp are used to examine the eyes when the pupils are dilated.

Walther[26] is reported to have said that everyone who does not die prematurely becomes cataractous. Koch[20] has referred to the high frequency of lens opacities.

The following table shows the incidence reported by various authors.

TABLE 1

AUTHOR	FREQUENCY	TYPE OF CATARACT
Vogt (32)	90% of people over 60 years of age	Senile
Diamond (9)	80% of all eyes	(?)
Doggart (10)	94% of men of military age	(?)
Doggart (11)	90% of children examined	(?)
Butler (6)	25% of all cases	Anterior Axial Embryonic
Butler (5)	10% of all cases	Vestiges of Pupillary Membrane
Bellows (3)	25% of all adults	Coronary
Wolfe (29)	25% of all adults	Coronary
Gifford (18)	85% of all persons over 80	(?)
Bellows (2)	5 to 10% of ocular complaints in larger clinics	(?)

The higher frequencies of cataract shown above are for minute opacities found by research methods. The frequency of clinically observed cataracts is somewhat less.

However, for the purposes of this paper cataract is defined as any opacity of the lens or capsule which can be seen by one or more of these instruments, retinoscope, ophthalmoscope, hand slit-lamp, or by the use of focal illumination. These are the opacities that the optometrist finds during the course of his examination of the patient's eyes, with the pupils in their normal state.

SELECTION OF CASES

A survey of the cataractous patients in the files of one optometrist* was then conducted. Just over 1,000 patients were found to have cataract in one or both eyes.

From this group all eyes which fulfilled all the following requirements were selected:

1. No cataract found (by optometric examination as described above) when the eye was first examined at this office and corrected visual acuity 20/30 or better.
2. Cataract observed on the occasion of a subsequent examination of the eye.
3. Cornea normal throughout the period under consideration. No scars, opacities, or deformations.
4. No congenital defects of the eye.
5. No history or signs of trauma in or about the eye.
6. Throughout the period under observation, no pathological changes other than cataract observed in or about the eye.
7. Patient returned to this office a minimum of four times for refraction and observation.

These limitations rule out as far as possible congenital, traumatic and complicated cataract.

When the corrected visual acuity became less than 20/80 astigmatic changes were no longer included in this study as it was felt that small changes in the cylinder power or axis were then likely to be ignored by the refractionist or he might at this stage prescribe lenses on the basis of the resultant sphere.

There were found to be 327 eyes (195 patients) which fulfilled the above requirements. The patients were refracted by one optometrist over a period of 30 years.

The average number of refractions per patient was eight; this in-

*H. A. Nott, optometrist and until his retirement, a Fellow, American Academy of Optometry.

cluded refractions both before and after the appearance of cataract.

DETERMINING THE ASTIGMATIC ERROR

For these patients, the refractionist made his decision on the astigmatic correction to be prescribed after doing all the following tests.

1. keratometer measurement of the cornea
2. static skiametry
3. dynamic skiametry by the Tait method
4. dynamic skiametry by the Nott method
5. subjective testing at 20 feet by the use of the Jackson flip cylinder to verify both the power and the axis of the correcting cylinder
6. subjective testing at 20 feet by the use of the 4 square chart
7. subjective testing at 16 inches by the use of the Jackson flip cylinder to verify both power and axis of the correcting cylinder

In addition the following tests were used on some of these patients for further verification of the cylinder power or axis.

8. rotating the correcting cylinder for subjective observation of blur at both 20 feet and 16 inches
9. use of the stenopaic slit
10. use of the fan dial
11. use of the Robinson-Cohen chart

RESULTS

Table 2 shows the difference between the power of the cylinder prescribed before cataract was found and that prescribed after cataract had existed for some time. Table 3 compares the positions of the cylinder axis after cataract was found with the position of the axis before cataract was found.

Since most writers postulate the development of against-the-rule astigmatism (minus cylinder axis vertical) the changes in cylinder power shown are the increases or decreases in the amount of against-the-rule astigmatism.

From Tables 2 and 3 it appears that there is a small but definite increase in against-the-rule astigmatism and a tendency for the axis of the minus correcting cylinder to swing toward the vertical meridian, coincident with the development of cataract.

Possible sources of error are first, the probability that many of these eyes already had minute lens opacities when first examined though none was seen in the course of their routine refraction. If this is so the above figures do not show the true difference between the astigmatic error of the eye when absolutely no cataract was present and the error after its development. A second source of error lies in the fact that the above changes in the astigmatic refraction of the eye took place over a long period of time, as much as 30 years, so that the changes may be the result of a change in astigmatism with time and the increased age of the patient. In other words the astigmatic change may be unrelated to the development of cataract though occurring at the same time.

TABLE 2

Changes in Power of Against-The-Rule Astigmatism After the Development of Cataract.

+ = more against-the-rule or less with-the-rule astigmatism.

— = less against-the-rule or more with-the-rule astigmatism.

Change in Diopters	*No. of Eyes*
— 1.50	1
— 1.25	1
— 1.00	1
— .87	1
— .75	2
— .62	3
— .50	14
— .37	5
— .25	31
— .12	8
0	95
+ .12	11
+ .25	52
+ .37	12
+ .50	34
+ .62	8
+ .75	24
+ .87	6
+ 1.00	12
+ 1.12	0
+ 1.25	3
+ 1.37	1
+ 1.50	1
+ 1.75	0
+ 2.00	0
+ 2.25	0
+ 2.50	1
Total number of eyes	327

TABLE 3

Changes in Axis of the Astigmatism After the Development of Cataract.

+ = axis of the minus correcting cylinder rotated toward the 90th meridian.

— = axis of the minus correcting cylinder rotated away from the 90th meridian.

Changes in Degrees	*No. of Eyes*
— 35	1
— 30	0
— 25	1
— 20	1
— 15	6
— 10	10
— 5	24
0	85
+ 5	29
+ 10	22
+ 15	15
+ 20	3
+ 25	7
+ 30	6
+ 35	2
+ 40	1
+ 45	1
+ 50	0
+ 55	1
+ 60	2
+ 65	1
+ 70	2
+ 75	1
+ 80	1
+ 85	1
+ 90	2
Total number of eyes	225

Eyes which were stigmatic before the development of cataract or which became stigmatic after the development of cataract are not included in Table 3.

THE CONTROL SURVEY

A control survey was therefore undertaken, using cases from the same source. These eyes showed no cataract at any time. The control group were examined and refracted in the same way with the same equipment by the same optometrist and over the same period of time. Consecutive records from the same files were studied and 535 eyes which fulfilled the conditions mentioned earlier were tabulated. Thus except for the presence of cataract in the first group and its absence in the control group all conditions and methods were identical. The control group shows the changes which occur in astigmatism in non-cataractous eyes over the same period of time as covered in the first survey. The

difference between the two surveys should show the astigmatic changes which are directly dependent upon the development of cataract.

ASTIGMATIC CHANGES WITH AGE

Most authorities state that the astigmatic error does change with the age of the patient. Duke-Elder [14, 15] says "The variation of regular astigmatism with age is of considerable importance. There is a general tendency for the direct astigmatism (the usual condition at birth) to

TABLE 4

Changes in Power of Against-The-Rule Astigmatism when no Cataract was found.
+ = more against-the-rule or less with-the-rule astigmatism.
— = less against-the-rule or more with-the-rule astigmatism.

Changes in Diopters	*No. of Eyes*
— 1.75	3
— 1.50	1
— 1.37	1
— 1.25	0
— 1.12	1
— 1.00	4
— .87	2
— .75	15
— .62	5
— .50	18
— .37	11
— .25	47
— .12	32
0	124
+ .12	33
+ .25	88
+ .37	21
+ .50	60
+ .62	17
+ .75	25
+ .87	7
+ 1.00	12
+ 1.12	2
+ 1.25	1
+ 1.37	1
+ 1.50	3
+ 1.62	1
Total number of eyes	535

TABLE 5

Changes in Axis of Astigmatism when no Cataract was found.
+ = axis of the minus correcting cylinder rotated toward the 90th meridian.
— = axis of the minus correcting cylinder rotated away from the 90th meridian.

Changes in Degrees	*No. of Eyes*
— 60	1
— 55	0
— 45	0
— 50	1
— 40	3
— 35	1
— 30	5
— 25	3
— 20	5
— 15	16
— 10	22
— 5	43
0	74
+ 5	69
+ 10	35
+ 15	32
+ 20	16
+ 25	12
+ 30	13
+ 35	7
+ 40	8
+ 45	3
+ 50	4
+ 55	2
+ 60	6
+ 65	4
+ 70	1
+ 75	2
+ 80	0
+ 85	0
+ 90	3
Total number of eyes	391

Eyes which were stigmatic when first refracted or which were stigmatic on the occasion of the last refraction are not included in Table 5.

decrease or inverse astigmatism to increase but the changes are within narrow limits. It follows that a young adult aged 30 with a small amount of direct astigmatism may become stigmatic at 45 and is likely to show some inverse astigmatism at 60 years." (He uses the term direct astigmatism for with-the-rule astigmatism and inverse astigmatism for against-the-rule astigmatism.)

Walton[17] on the other hand concludes "the cylindrical findings regardless of the number of years between the first and last examination show a change of 00.0 diopters." In his group of patients where the elapsed time between first and last refraction is 20 to 29 years 27.12 per cent showed no change in cylinder power and 52 per cent showed only ± 0.25 diopters or less change. Kratz and Walton[21] state "over the 14 years the subjective cylinder did not change more than ± 0.25 in 60.2 per cent of the cases."

Our control group showed the following results. Tables 4 and 5:

When tabulated the results show:

TABLE 6
FIRST REFRACTION

	When Cataract Was Found	*When Cataract Was Not Found*
Number of eyes with cataract	327	
Number of eyes in control group		535
Astigmatic when first refracted	81.0%	79.1%
Stigmatic when first refracted	19.0%	20.9%

TABLE 7
Final Refraction

Number of eyes	327	535
Astigmatic at final refraction	78.9%	87.5%
Stigmatic at final refraction	21.1%	12.5%

TABLE 8
Changes in Cylinder Power

Number of eyes	327	535
Increased against-the-rule astigmatism	50.5%	50.7%
Decreased against-the-rule astigmatism	20.5%	26.2%
No change in power of cylinder	29.0%	23.2%

TABLE 9
Changes in Cylinder Axis

Number of eyes with astigmatism at both first and final refraction	225	391
Axis swung toward the 90th meridian	43.1%	55.5%
Axis swung away from the 90th meridian	19.1%	25.6%
No change in axis	37.8%	18.9%

TABLE 10
Eyes With No Astigmatism When First Refracted

Number of eyes	62	112
Developed against-the-rule astigmatism	45.2%	48.2%
Developed with-the-rule astigmatism	8.1%	20.5%
Remained stigmatic	46.8%	31.3%

TABLE 11

Eyes Originally Astigmatic Which Became Stigmatic

	When Cataract Was Found	*When Cataract Was Not Found*
Number of eyes	40	32
Increased against-the-rule astigmatism	50%	84.4%
Decreased against-the-rule astigmatism	50%	15.6%

TABLE 12

No Astigmatic Changes

i.e., if astigmatic no change in cylinder power or axis or if stigmatic remained stigmatic

Number of eyes refracted	327	535
No astigmatic changes whatever	19.3%	8.4%

TABLE 13

If it is considered that the limit of clinical accuracy is ± 0.25 diopters in power and 5 degrees either way in the axis then the principal figures given above become those shown in Tables 13 and 14.

Of All the Eyes

Increased against-the-rule astigmatism	31.2%	28.0%
Decreased against-the-rule astigmatism	8.6%	11.4%
No change in the amount of the astigmatism	60.2%	60.6%

TABLE 14

(Minus Cylinders used)

Of Those Eyes With Astigmatism Throughout

Axis swung toward the 90th meridian	30.2%	37.9%
Axis swung away from the 90th meridian	8.4%	14.6%
No change in the cylinder axis	61.3%	47.6%

CONCLUSIONS

The similarity between the two sets of figures in the preceding tables would seem to indicate that there is not a great interrelationship between astigmatic changes and the development of cataract. The converse theory has been advanced that uncorrected refractive errors particularly hypermetropia and astigmatism act to cause cataract.[7] Most modern writers consider this hypothesis unproven.[16] Before conclusions either way are drawn, the records of other groups of patients in other practices should be studied. Approximately 5 per cent of all new patients coming to the writer have some cataract when seen for the first time.

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ABSTRACTS

COLLEGIATE INSTRUCTION AND LABORATORY TRAINING IN OPHTHALMIC OPTICS. Charles Sheard. Guildcraft. XXV.9.25-32. 1951.

The author reviews the recent developments in collegiate training in the field of ophthalmic optics, outlining the work presented at the Rochester Junior College, the New York State Institute of Applied Arts and Sciences, and the course in opticianry presented at the Los Angeles City College. The author points out that the purposes of these courses are to better train opticians so that they may more adequately serve optometrists and ophthalmologists.

C. C. K.

CONTACT LENS CLINICS OF THE LONDON REFRACTIVE HOSPITALS*

A COMPARISON WITH THE CLINICS OF THE PENNSYLVANIA STATE COLLEGE OF OPTOMETRY

Euin Steele†
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I have read with interest the report by Russell S. Manwiller of the contact lens clinic established by the Pennsylvania State College of Optometry.

I feel it may be of interest to your readers, especially those associated with the Philadelphia clinic, to learn of the conditions and treatment applied at the London Refraction Hospital contact lens clinic which is the English counterpart of your own.

I first learned of the free eye clinic established by the Pennsylvania State College of Optometry when I visited the United States in 1947 and had the pleasure of meeting Dr. John C. Neill. I was then impressed by the marked resemblance of this clinic to the London Refraction Hospital, both having the same *raison d'etre*—namely the provision of aid for necessitous patients, and of clinical training for advanced students. At about the time I left England for the States the London Refraction Hospital, which had been running both full and part-time contact lens courses for some years, decided to commence a contact lens clinic for the very reason which has prompted the formation of your own—to provide actual patient experience as a supplement to the hospital's theoretical and practical courses.

There is a very marked similarity indeed in the method of selecting patients for the contact lens clinic. Cases may be referred direct to the hospital by practicing optometrists who feel that contact lenses are indicated or may be selected by the refraction clinic of the hospital for reference to the contact lens clinic. In every instance the patient is first examined by the refraction clinic. Patients are referred to the contact lens clinic for the same reasons as given by Manwiller, namely:

1. Occupational needs of the patient.
2. Inadequacy of ordinary ophthalmic correction in what may be regarded as pure refractive cases involving low acuity, loss of field, etc. (as in high myopia).

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3. Pathological cases involving low acuity uncorrectable with spectacle lenses (such as nebulae, leucomota, keratoconus, aphakia, etc.).

Before these patients are actually treated by the contact lens clinic they are sent to the hospital secretary for what may be described as a means test. If the secretary considers the patient is in a position to meet private fees for such treatment the patient is given a list of certified contact lens practitioners and is instructed to obtain his treatment privately. If the secretary feels that the patient's circumstances do not permit this expense he agrees that the patient shall be fitted by the hospital but if economic conditions permit, the patient is asked to pay the laboratory costs of the lenses. The staff who undertake the fitting of these patients are voluntary workers, all clinical staff appointments at the hospital being honorary.

From the foregoing it is obvious that a marked parallel can be drawn between the British and American clinics—the one difference being that the London clinic has not so far received television publicity!

While there is this marked semblance between the constitution of, and selection of, patients for the two clinics, there is, I think, a considerable difference of view as to choice of fitting technique. I note that of 10 cases fitted at Philadelphia, Manwiller reports that eight were fitted with tangent cone lenses and the remaining two were molded. The reverse, I think, would have been the case at the London Research Hospital. Furthermore, I note that no mention is made of the use of capillary touch or fenestrated lenses.

It will, therefore, at least be of academic interest if a description is given of the techniques generally adopted by myself and my colleagues at the London clinic. Here I should mention that each contact lens practitioner (who takes charge of the clinic on his own duty night) makes his own decision as to what technique he will adopt in any given case and the following is a description of the techniques adopted by myself and by some, at least, of my colleagues.

At the end of 1947, following the return to England of a number of British practitioners who had visited the United States, tangent cone lenses became very popular and were fitted to a large number of patients. Results varied and while some patients obtained very satisfactory wearing times there were many more who did not. Again, where the sclera proved very irregular in shape considerable adjustments had to be made by pliering. It was felt in these cases that a far more satisfactory fit could be obtained by moulding the patient in the first instance. The marked variance in wearing time—which was normally limited by the onset of veil and not by physical comfort—caused a good deal of

thought and I formed the opinion that this was not due to some basic difference in the metabolism of corneas but in the depth of the fluid lens created between one patient and another. To enlarge this point a little, if one fits a patient with preformed lenses it is immaterial whether the lens gives apical clearance or not. If, however, it does clear the cornea there is no means of determining by how much. It is my opinion that the conical lenses which give satisfactory wearing time are those which give a minimum of corneal clearance.

This conclusion led, in Britain, to the fitting of what are termed minimum corneal clearance lenses. The procedure is to take a mold of the eye and then prepare a shell giving corneal touch. Controlled grind-outs are then made until the optic just clears the cornea. It is obvious that by this means the amount of clearance can be accurately determined. This type of fitting has largely replaced the former type of fluid lens, whether preformed or molded, and is known as capillary touch. Capillary touch lenses have shown a marked improvement in wearing time over the fluid lens but in certain circumstances and in certain cases still do not give as long a wearing time as is desirable. Practitioners who have adopted this technique find that the capillary touch lens affords the patient approximately twice the period of veil-free wear obtained with a fluid lens. It would seem therefore that by eliminating the fluid lens the problem of veiling is at least partly solved. That it is not entirely solved is evidenced by the fact that it is found necessary in certain cases to fenestrate the lenses in order to improve the wearing time. This is further proof that the fluid lens is not the sole causative agent of Sattler's Veil. Interference with the respiration of the cornea is thought to be—and probably is—a contributory factor to veiling. By fenestration of the pari-limbal portion of the haptic an air bubble is introduced which encircles the cornea but does not cross it. This enables a free exchange of CO_2, discharged from the surface of the cornea, and oxygen.

It can be appreciated that the correct fitting of a fenestrated lens calls for considerable skill and patience but the results which have been obtained more than justify the time and patience expended. Veiling with this type of lens is non-existent and most patients can wear their lenses for periods of 10 hours—in some cases considerably longer. There is a further advantage in that solutions are dispensed with entirely, the patient merely wetting the lens prior to insertion. While the majority of English practitioners prefer to fenestrate a shell taken from a mold, fenestration can be applied to preformed lenses. In this case it is wise to obtain the collaboration of the laboratory in advance as numerous adjustments may have to be made to the inner surface of the optic.

The lens should therefore be supplied in semi-finished form, the outer optic curve being calculated after the final fitting adjustments and tolerance tests have been made.

I would like to illustrate the advantages of the fenestration technique by quoting the case of a Hospital patient, Mr. J. P., who was sent to my clinic for treatment. This patient was highly myopic in the right eye, having a spectacle correction in the region of —35.00 diopters. The left eye was blind as the result of three unsuccessful cataract operations and had become slightly microphthalmic. The vision obtained with the spectacle correction in the right eye was 6/18— with a marked reduction in field. I molded this patient and fitted him with a capillary touch lens which gave him an acuity of 6/9+ together with a normal field of vision. He wore this lens with comfort for a period of five hours. At the end of this time he experienced haze which compelled him to remove the lens and resort to his spectacles until the haze cleared. Having regard to his low acuity with spectacles the added haze seriously handicapped him at work and I decided to fenestrate the finished lens. This necessitated additional adjustments to the haptic but the patient is now able to wear his lens for periods of 10 hours or more and experiences no veil. A further interesting aspect of this case was that I fitted the blind eye with a shell for cosmetic reasons. This was not fenestrated and, subsequent to the fenestration of the right lens, the patient found that his right eye veiled after five hours wear of this shell in the left eye. If the shell is not worn in the left eye no veiling occurs in the right.

CONCLUSION

I have attempted to show, in this brief article, how much the clinics of the Pennsylvania State College of Optometry and the London Refraction Hospital have in common. I would like to wish Dr. John C. Neill and his collaborators the success which I know they deserve. I hope that perhaps my references to the fenestration technique may encourage its adoption at the Philadelphia clinic as I am sure it will be found of value at least in those cases which do not respond satisfactorily to other types of lenses.

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THE MAGNITUDE OF THE PULFRICH STEREOPHENOMENON AS A FUNCTION OF DISTANCE OF OBSERVATION*

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The present experiment is concerned with a stereoscopic effect first described and analyzed by Pulfrich *(2)*. The stereophenomenon is readily demonstrated by means of a pendulum-bob made to oscillate in a frontal frontal plane and on a level with the eyes. With binocular fixation maintained at a point directly below the oscillating bob, midway between the end-points of its swing, the path traversed by the bob appears to be confined approximately to the plane of oscillation and identical for either direction of stroke. When a smoked glass is placed before one of the eyes, however, the oscillating bob appears to rotate out of its plane of oscillation. The direction of the apparent rotation of the bob reverses itself when the smoked glass is placed before the other eye. As viewed from above, the apparent rotation is clockwise when the smoked glass decreases the illumination of the left eye and counterclockwise when it decreases the illumination of the right eye. The effect becomes noticeable at some threshold value and increases as the difference in the intensity of illumination between the two eyes increases. The effect is also elicited when a colored filter is substituted for the smoked glass.

THEORETICAL EXPLANATION

As analyzed by Pulfrich, the phenomenon is shown to be consistent with the law of corresponding retinal points and the general principles of space perception. The explanation is based on an hypothesized visual latent period whose magnitude is presumed related to a reciprocal function of the intensity of the illumination.

Simultaneous stimulation of corresponding retinal points will result in simultaneous "excitations," but only after a brief delay which becomes shorter as the stimulus-illumination increases. By placing the smoked glass before one eye, the stimulus-intensity for that eye is decreased. As a result, the time course of "excitations" from corresponding retinal points will no longer be simultaneous for the two eyes. Hence, for a

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transversely moving object, synchronous "excitations," at any given moment, will have arrived from slightly different retinal points, the amount of disparity increasing as the difference in brightness existing between the two retinal images becomes greater. Accordingly, the stereoscopic illusion produced is that the oscillating bob appears to move in a path which locates the bob nearer than it really is for the one direction of stroke, and farther than it really is for the return stroke.

GEOMETRIC ANALYSIS

An understanding of the effect may be obtained from an analysis of Figure 1 which is drawn to represent the horizontal plane of fixation, and contains the centers of rotation of the two eyes designated by Z_R and Z_L. The figure is meant to represent the stereoscopic space-image at the exact moment that the bob, P_{LR}, moving from left to right in its path W_1W_2, seems to be passing *in front of* the plane of oscillation, directly over the point P'_N located in the vertical median plane towards which the eyes are converged. Also represented is the situation when the bob (now designated by P_{RL}) is moving from right to left and seems to be passing *behind* the plane of oscillation, directly above the point P'_F located in the vertical median plane towards which the eyes are now supposed to be converged. The filter, as indicated, is retained before the right eye.

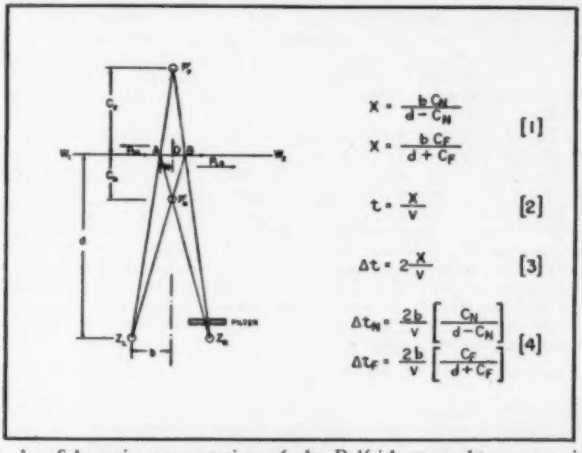

Fig. 1. Schematic representation of the Pulfrich stereophenomenon indicating the stereoscopic space-image in the horizontal plane of fixation.

When the bob is moving from left to right and appears to be passing directly above the fixation point P'_N, at the near position, then in accordance with the laws of space-projection, the excitation of the left eye was initiated when the bob (now at PLR) was at the point B. Synchronous excitation for the right eye was initiated when the bob was at the point A, a bit farther behind in its path. The time taken for the bob to move from B to PLR represents a theoretical absolute latency for the

left eye, and the time taken for the bob to move from A to P_{LR} represents the slightly longer absolute latency for the right eye with filter. The latency difference (Δt_N) between the two eyes, for the near position, can then be expressed as the time taken for the bob to move from A to B.

By the same reasoning, when the bob is moving from right to left and appears to be passing directly above the fixation point P'F, at the far position, the time taken for the bob to move from B to A represents the latency difference (Δt_F) between the two eyes. If the velocity of the moving bob is symmetrical on both sides of the vertical median plane, then $\Delta t_N = \Delta t_F$.

From Figure 1 it is evident that for the apparent positions of the bob at P'N and P'F respectively,

$$X = bC_N/(d\text{-}C_N) \text{ and } X = bC_F/(d+C_F) \quad [1]$$

where X = ½ the distance from A to B; b = ½ the distance between the centers of rotation of the two eyes; d = observation distance measured in the vertical median plane from the line joining the centers of rotation; and C_N and C_F represents the distances OP'N and OP'F, respectively.[1]

If the velocity of the moving bob is known, it is possible to calculate the latency difference which results from any difference in retinal brightness between the two eyes by experimentally determining the distances OP'N (C_N) or OP'F (C_F).

Consider the case in which a vertical rod is made to oscillate with constant velocity (V) in a frontal plane, its path denoted by W_1W_2 (Figure 1).[2] The time (t) required for the rod to move through the distance AO (X) is given by the formula:

$$t = X/V \quad [2]$$

The time taken for the rod to move from A to B (or B to A), which represents the latency difference between the two eyes, can then be calculated from the formula:

$$\Delta t = 2X/V \quad [3]$$

Substituting for X the relations obtained in Equation [1] we obtain, finally, $\Delta t_N = (2b/V)\,[C_N/(d\text{-}C_N)]$, and $\Delta t_F = (2b/V)\,[C_F/(d+C_F)]$ [4]

The distances C_N and C_F are hereafter referred to as the near and far displacement of the oscillating target, respectively, and the corresponding latency differences Δt_N and Δt_F, as calculated from Equation [4], are referred to as the near and far latency difference between the two eyes. The greater the displacement, the greater is the stereoeffect.

From purely geometric considerations it is to be noted that, for any constant intensity difference produced between the two eyes, an increase in the observation distance results, theoretically, in an increased stereoeffect, if the corresponding calculated latency differences are to remain constant in magnitude. Similarly, an increase in the velocity of the oscillating target at any given observation distance results in an increased stereoeffect for a constant calculated latency difference. It is to be further noted that, under any given set of conditions, the displacement is theoretically greater when the rod appears to travel behind its plane of oscillation than when in front of its plane of oscillation ($C_F > C_N$). The difference between the two displacements becomes theoretically more marked as the observation distance is increased, and also as X is made larger by increasing the difference in intensity between the two eyes or increasing the velocity of the oscillating rod.

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[1] If the observation distance, d, is measured in the vertical median plane from a reference line other than the one joining the centers of rotation of the eyes (e.g., a line joining (1) the centers of the artificial pupils; (2) the corneal vertices; (3) the principal points of the eyes; (4) the nodal points of the eyes) Equation [1] is still applicable, provided b is now taken to represent ½ the distance between the new points of reference (i.e., ½ the distance between (1) the centers of the artificial pupils; (2) the corneal vertices; (3) the principal points; (4) the nodal points). The small error which may be introduced by displacements of the selected reference points from the visual axes is neglected in this treatment.

[2] See Lit (*1*) for a similar analysis in the case of a target made to oscillate in a frontal plane with simple harmonic motion.

PREVIOUS EXPERIMENTS

The Pulfrich stereophenomenon has been investigated from many aspects, and the extensive literature summarized by Lit (*1*). With respect to photometry, duplicity theory and clinical applications, a brief summary and evaluation of the obtained results follows:*

(*1*) *Heterochromatic photometry.* Pulfrich employed the stereophenomenon as a new method of heterochromatic photometry. With a colored filter placed before one of the eyes, the colored illumination was then matched with illumination obtained through a graded series of neutral or tinted filters placed before the other eye. Intensity balance for the two eyes was said to exist when the oscillating bob again appeared to move in its true plane of oscillation. The limitations of this method were first established by Von Kries[3] and his co-workers, Engelking and Poos.[4] Heterochromatic matches were consistent with those obtained by other photometric methods only when the observations were made under conditions of high illumination.

(*2*) *Duplicity theory.* Von Kries and Engelking and Poos reported peculiar effects when observations were made with one eye dark-adapted and the other eye light-adapted. Although the image seen by the dark-adapted eye appeared brighter, the direction of rotation of the pendulum indicated a greater latency for that eye. Also, despite the shift in maximal sensitivity towards the blue end of the spectrum following dark adaptation (Purkinje phenomenon), the magnitude of the stereoeffect indicated a smaller visual latency when a red rather than a blue filter was placed before the dark-adapted eye. These effects were attributed to a latency differential in the perceptions mediated by the rod and cone mechanisms of the retina, the latency being presumed greater for the rod mechanism.

(*3*) *Clinical applications.* The stereophenomenon has been used to test individuals possessing defective color vision. The responses to different colored lights, obtained during the course of dark-adaptation, were correlated with type of color vision deficiency.[5] Liang and Piéron[6] have obtained data which indicate the usefulness of the stereophenomenon as a method for testing color-vision theory.

The application of the stereophenomenon in clinical practice for the early detection of ocular pathology was attempted by Sachs,[7] who found it an extremely sensitive method. With equal illumination presented to each eye, a stereoeffect may be elicited as a result of any optical or ocular condition which produces a difference in the intensity of the retinal images (differentially tinted lenses, anisocoria, corneal or lenticular opacities, etc.). Furthermore, under conditions of equal retinal illumination, the stereophenomenon may also be expected to occur as a result of any visual or systemic pathology which produces a unilateral delay in the transmission of nerve impulses from the retina to the cerebral cortex (retinal pathology, brain tumors, etc.).

Experiments have also been reported on the relationship between the stereophenomenon and stereoscopic acuity.[8]

A PROGRAM OF RESEARCH

Despite the considerable work done, a systematic investigation of the variables which influence the magnitude of the stereophenomenon has not been undertaken. The results reported by previous investigators have shown considerable variability, but these results, obtained under

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*To avoid duplication of the extensive bibliography, mention will be made only of the footnote in Lit's paper where the complete references may be obtained.

[3]Lit (*1*): Footnote 9.
[4]Lit (*1*): Footnote 10.
[5]Lit (*1*): Footnote 13.
[6]Lit (*1*): Footnote 17.
[7]Lit (*1*): Footnote 15; also see footnote 14.
[8]Lit (*1*): Footnotes 12, 16.

different stimulus conditions, cannot be directly compared until the inter-relationships among the stimulus variables have been established. Before attempting to test for individual differences in response, the optimal conditions for testing the stereophenomenon experimentally and applying it clinically will have to be determined. To this end, a program of research designed to obtain complete stimulus specification is required.

Listed below are some of the basic variables which may be expected to influence the magnitude of the stereoeffect and require parametric analysis.

I. The intensity difference in the illumination presented to each of the eyes.
II. The basic level of illumination at which the given difference in retinal illumination occurs.
III. The distance of the plane of oscillation from the eyes.
IV. The velocity of the oscillating target.
V. The width, form and extent of travel of the oscillating target.
VI. The spectral composition of the illumination.
VII. The brightness-contrast between figure and field.

The parametric investigations specified in I and II provide data relating to the theory of space perception, the theory of intensity discrimination and the relationship between the hypothesized *absolute* visual latent period and intensity of illumination.

The independent variables specified in III (distance of observation) and IV (velocity of oscillating target) are essentially "geometric" in that their influence upon the magnitude of the stereoeffect is predictable from the geometric analysis of the theory of the Pulfrich stereophenomenon discussed in an earlier section of this paper. Any significant departure from predicted effects obtained in III may require analysis in terms of the laws of space perception: departure from predicted effects in IV may provide data for a theory of retinal interaction. Additional data more directly related to retinal interaction effects may be provided by the results obtained from the studies indicated in V (width, form and travel of target) and VII (brightness-contrast).

The results obtained from VI (spectral composition of illumination) will bear most directly on theories concerned with color vision.

In addition to providing appropriate data for theories concerned with some of the most basic visual processes, the results of the proposed research program should also offer many useful clinical and industrial applications.

The study of the influence of binocular differences of intensity produced at various levels of illumination (I and II) has already been undertaken and reported by Lit (*1*). His results indicate that the magnitude of the stereoeffect depends not only upon the intensity difference produced between the two eyes, but also upon the basic level of illumination at which the intensity difference exists. From his data and interpretation, it may be possible to determine an empirical equation which describes the relationship existing between the hypothesized *absolute* visual latent period and level of illumination. To avoid deriving an equation of limited significance (limited by the unique values selected for the observation distance, target velocity, target size, etc.)

the calculation has been deferred pending investigation of the influence of the stimulus variables requiring parametric analysis. It is the purpose of the present study to investigate III, the effect of the distance of observation upon the magnitude of the stereoeffect.

APPARATUS AND PROCEDURE*

Apparatus: The apparatus used is schematically presented in Figure 2A. The subject is seated in a dark room (D), and binocularly observes the fixation target (FT) and oscillating target (OT) through a pair of circular artificial pupils (E), 2.5 mm. in diameter and adjustable for interpupillary separation. The artificial pupils are attached to eye-tubes which are mounted on the dark room inner-wall. In front of each eye-tube, a filter box (F) is mounted to the outer-wall surface so that by use of appropriate filters the experimenter may control the illumination presented to each eye. The subject's head is kept immobilized by chin and forehead rests.

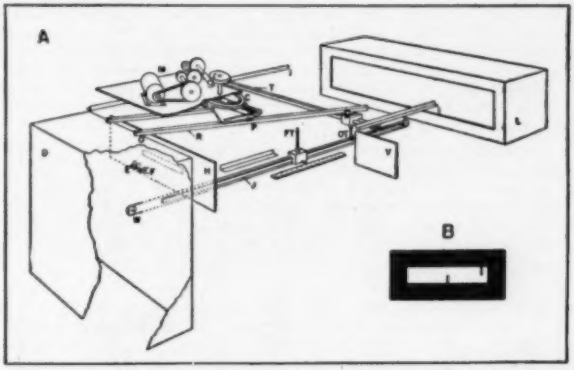

Fig. 2A. Schematic Representation of the Apparatus. The subject is seated in a dark room (D) and binocularly observes the fixation target (FT) and the oscillating target (OT) through a pair of artificial pupils (E). The movement of the oscillating target is restricted to reciprocating constant motion, in a frontal plane, with angular velocity at the subject's eyes identical for each distance of observation. The fixation target may be moved in the vertical median plane either towards or away from the subject by means of the pulley-wheel (W) located in the dark room. The position of the fixation target is read from a millimeter scale. Background illumination is provided by a light box (L). Filters placed in the filter boxes (F) control the illumination presented to each eye. The field of view in the horizontal extent is regulated by a pair of screens (V) placed in the plane of the oscillating target; the vertical extent is determined by the horizontal slit in screen (H). The angular extent of the

*The writers wish to express appreciation to their colleague, Professor Edwin W. Bechtold, for his many helpful suggestions in the design of the apparatus. The apparatus was constructed by Mr. Lloyd K. Dutton and Mr. James L. Woods of the Pupin Laboratories, Columbia University.

rectangular field of view remains constant for all observation distances.

Fig. 2B. View of Targets as Seen by the Subject. Both targets are seen against the uniform white background produced by the light box. The lower rod is the fixation target located in the subject's vertical median plane. The upper rod is the oscillating target shown at a displaced position in its frontal plane movement. Both angular extent of field and angular size of targets are maintained constant for all distances of observation.

The apparatus consists of three major components: (a) the oscillating target, (b) the fixation target, and (c) the lighting and screening units.

(a) Oscillating target. The oscillating target and its drive mechanism are mounted in a braced angle-iron framework. The oscillating target (OT) is a blackened steel rod rigidly suspended, vertically downward to eye level, from a Jacob's chuck in which it is retained. The chuck is centrally mounted on the undersurface of a supporting carriage which rides on horizontal tracks (T). The tracks can be set in a frontal plane at any predetermined distance from the subject's eyes and clamped to supporting angle-iron rails (I). A slot is cut in the upper surface of the carriage, directly above the Jacob's chuck and perpendicular to the tracks. The carriage receives its movement from a horizontally oscillating drive-rod (R) which is pivoted at position O, a point located in the subject's vertical median plane directly above the line joining the principal points of the eyes. A pin mounted on the undersurface of the drive-rod engages the slot cut in the upper surface of the carriage. The position of the pin from the pivot point (0) is adjustable. Power for the drive-rod is provided by a cam-regulated mechanism (C) which converts constant angular velocity into reciprocating linear velocity, with the central 90 per cent of stroke at constant speed. The power to the drive-rod is applied at a vertical pivot pin (P), permanently mounted of the drive-rod engages the slot cut in the upper surface of the carriage. The position of change gears for control of output r.p.m. in step intervals, provides the cam mechanism with the required angular velocity. Constancy of input r.p.m. for the gear train is maintained to within a 1 per cent error by rheostat regulation of the motor current; constancy is checked with a stroboscopic device.

The oscillating carriage and its drive mechanism, designed to convert constant angular velocity into oscillating linear velocity of constant magnitude in a frontal plane, is shown in plan view in Figure 3. The oscillating target is not indicated. It is suspended from the undersurface of the oscillating carriage (OC) which rides on track (T), clamped on angle-iron rails (I). The carriage is moved by the drive-rod (R), pivoted at O. When the gear train is in motion, the fork-shaped arm (A) rotates with

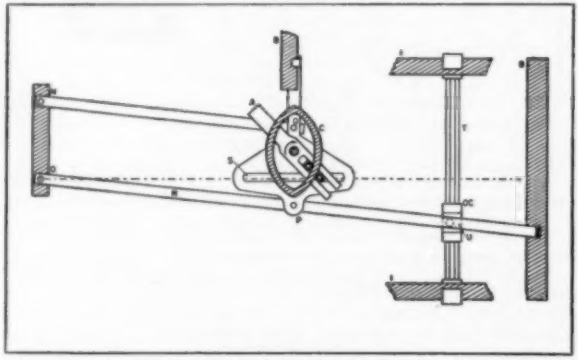

Fig. 3. Mechanism for Providing Horizontal Reciprocating Motion in a Frontal Plane. Speed of OC is constant for the central 90 per cent of stroke and its angular velocity, measured at the subject's eyes [located below (O)], is made identical for all distances of observation.

constant angular velocity in a direction indicated by the arrow. A follower-carriage which rides in the slotted portion of the arm mounts two rollers, a fixed distance apart, on its upper surface. The position of the carriage from the center of rotation of the arm is determined by a ring-shaped cam (C) on whose inner and outer surfaces the rollers ride. The inner surface of the cam is designed to complement its outer surface so that the follower-carriage, through its rollers, receives positive drive at all positions of the rotating arm. The left and right halves of the cam are symmetrical about the Y axis (defined as the line contained in the frontal plane passing through the center of rotation of the arm). The path traced by the center of the outer roller for the right half of the cam is described by the equation, *

$$\rho = a\theta/\sin\theta \qquad [5]$$

where ρ = radial distance of the outer roller from the center of rotation of the arm; θ = angular distance of the outer roller from the X axis; and a = a constant (distance between center of rotation of the arm and the center of the outer roller when θ equals zero). When the rate of change of θ is constant, the velocity of the frontal plane component (dy/dt) of the outer roller becomes:

$$dy/dt = 2\pi a/T = \text{a constant} \qquad [6]$$

where $2\pi/T$ equals $d\theta/dt$ and T represents the time required for one complete revolution of the arm (A).

The path of the outer roller, described by Equation [5], is also traced by a pin, mounted below the outer roller and projecting from the undersurface of the follower-carriage. The pin engages a slot (S) which is cut perpendicular to the line of bearings of a link pivoted at P and Q. Link PQ is a member of a parallelogram linkage system pivoted at N, O, P and Q. Because PQ remains parallel to a link (ON) permanently fixed in a frontal plane, the slot (S) in PQ is always oriented perpendicular to a frontal plane. Therefore, the frontal plane velocity component of link PQ is identical with that of the pin projecting from the follower-carriage. This velocity component is in turn transmitted to the drive-rod (R) through pivot P. Thus, any point on the drive-rod moves on a circular arc and with a velocity component of constant magnitude in a frontal plane. The drive-rod, through a pin clamped on its undersurface (located at the same distance from O as the plane of the oscillating target), engages the oscillating carriage at slot U. The slot is oriented perpendicular to a frontal plane so that the oscillating carriage responds only to the frontal plane component of the drive-rod pin.

The apparatus may be modified to deliver simple harmonic motion to the oscillating carriage. This is accomplished by removing the cam and follower-carriage mechanism and mounting the pin, which engages slot S, in a fixed position on the rotating arm (A). In this case the equation representing the path travelled by the pin is,

$$\rho = c \qquad [7]$$

where c = a constant (radial distance of the pin from the center of rotation of the arm). The velocity of the frontal plane component then becomes,

$$dy/dt = (2\pi c/T)\cos\theta \qquad [8]$$

This modification does not alter the condition of identical angular velocity of oscillating target (measured at the point 0) for all distances of the plane of oscillation.

In the present experiment, the oscillating target is free to execute constant linear motion in a frontal plane at any specified distance from the subject.[9] Although the magnitude of the angular velocity of the oscillating target remains identical for all target distances, its linear magnitude varies with distance from the subject. Six positions of the oscillating target were selected. The observation distances (= d) corresponding to each of the target positions are: 30 cm., 60 cm., 80 cm., 100 cm., 120 cm. and 150 cm. The linear velocities of the oscillating target (= V), expressed in centimeters per second, for each of the distances of observation are: 9.91, 19.81,

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*The cusps which result from the intersection of the symmetrical equations describing the right and left paths of the outer roller have been rounded for mechanical reasons.

[9]Hereafter, specification of distances ("measured from the subject") or of angular magnitudes ("subtended at the subject's eyes") will be made in reference to the point of intersection of the subject's vertical median plane and the line joining the principal points of the eyes. The position of each principal point is taken to lie inside the eye at a distance of 1.3 mm. from the corneal vertex.

26.41, 33.02, 39.62 and 49.52, respectively; measured at the subject's eyes each of these linear velocities is equivalent to an angular velocity of 18.91° per sec. The angular extent of stroke of the oscillating target is maintained at 20.5° of visual angle for all observation distances. The angular size of the oscillating target is maintained constant (8.7 minutes of arc) by employing rods whose diameters at each of the testing positions measure 0.75 mm., 1.50 mm., 2.00 mm., 2.50 mm., 3.00 mm. and 3.75 mm., respectively.

(b) Fixation target. The fixation target (FT) is of the same form, color and size as the oscillating rod selected for the given observation distance. It is held upright in a Jacob's chuck which is mounted on the upper surface of a supporting carriage. The carriage rides on a horizontal metal track (J) located in the subject's vertical median plane. The height of the upper end of the fixation target is set on a level with the subject's eyes; when the fixation target is directly below the oscillating target, the targets appear contiguous.

The supporting carriage is made part of an endless-cable and pulley system. By means of a pulley-wheel (W) located in the dark room, the subject may adjust the position of the fixation target, in the vertical median plane, in a direction either towards or away from his eyes. The position of the fixation target is read from a two-meter scale (calibrated in millimeters) which is in contact with a vernier index mounted on the supporting carriage. Free from observable backlash, the mechanism permits the experimenter to estimate the position of the fixation target to within 0.1 mm.

(c) Lighting and screening units. Uniform background illumination is provided by ten 100-watt frosted lamps appropriately mounted in an asbestos-lined, galvanized-iron light box (L) located in a frontal plane 250 centimeters from the subject's eyes. Lamp voltage is maintained constant at 123 volts A.C. by rheostat control. The illuminated surface is a white matte screen attached to the inner rear-wall of the light box. The screen is visible to the subject through a horizontal aperture (165 cm. x 20 cm.) cut out of the front wall of the light box. The brightness of the screen is 610 millilamberts as calculated from measurements with a Macbeth illuminometer. For an artificial pupil 2.5 mm. in diameter, this is equivalent to a retinal brightness of 9510 photons.[10] Differences in retinal brightness between the two eyes are obtained by placing appropriate neutral Wratten filters in the filter boxes (F) provided.

The screening unit is designed to present the subject with a rectangular field of view whose angular dimensions are identical for all distances of the oscillating target. A constant angular extent of field of 4.2° in the vertical direction is obtained by a horizontal slit (26 cm. x 1.5 cm.) cut, at eye level, in a black screen (H) located 21 cm. in front of the subject. A constant angular extent of field of 21.6° in the horizontal direction is obtained by means of a pair of vertical screens (V) [only one is shown in Figure 2A] adjusted symmetrically in the plane of the oscillating target, 0.5° beyond the end-points of its reciprocating stroke. Placing the vertical screens in the plane of oscillation serves to minimize physiological diplopia; placing the horizontal slit close to the subject provides for complete freedom of movement of the fixation target at all target stations. As shown in Figure 2B, the subject sees the upper end of the fixation target and the lower end of the oscillating target contained within a constant angular field of view, for all distances of observation, against the uniform white background produced by the light box.

Procedure: A well trained, emmetropic subject (A.H.) with normal visual acuity and good stereopsis was used. Before testing at each of the six observation distances (d = 30 cm., 60 cm., 80 cm., 100 cm., 120 cm. and 150 cm.), the separation between centers of the artificial pupils was adjusted to conform to the changes in convergence position of the eyes; the inter-principal point separation of the eyes at each of the observation distances was calculated to be, respectively, 64.8 mm., 65.9 mm., 66.2 mm., 66.3 mm., 66.5 mm. and 66.6 mm. (= 2b in accordance with footnote [1], above). At each distance of observation, the subject made settings under conditions which included seven differences in retinal brightness between the two eyes. The retinal illumination of the right eye, I_R, was kept constant at

[10]Photons = $(10/\pi)$ x pupil area in square millimeters x brightness in millilamberts.

300 photons (log I_R = 2.478) by retaining a filter of optical density 1.50 (= 3.16% transmission) before the eye. The retinal illumination of the left eye, I_L, was increased in discrete steps by employing filters of optical density 1.40, 1.30, 1.00, 0.70, 0.50, 0.20 and 0.00. For the above stated conditions of retinal illumination the calculated values of log (I_L/I_R) are: 0.1, 0.2, 0.5, 0.8, 1.0, 1.3 and 1.5 respectively. The order of testing at the six distances of observation was randomized and testing at any one of the distances of observation constituted a session.

In any given experimental session, a 30-minute period of dark adaptation preceded the observations. With filters of equal optical density (1.50) placed before the eyes (I_L = I_R = 300 photons) the oscillating target was held stationary and laterally displaced 5.73° to the right or left of the subject's vertical median plane. The subject was required, at the given distance of observation, to position the fixation target with respect to the displaced oscillating target until both appeared to lie in a frontal plane. Five such determinations of frontal plane alignment were made at each of the two laterial positions of the oscillating target to obtain a measure of the subject's stereoscopic sensitivity at each of the six distances of observation. In addition, under conditions of equal retinal illumination (I_L = I_R = 300 photons), the oscillating target was set into motion, and the subject was required to adjust the fixation target directly below what appeared to be the frontal plane of oscillation. Ten settings were made at each distance of observation to obtain a measure of the localization error of the oscillating target when in motion [Lit (*1*), pp. 179-180.]. Following these preliminary settings, the basic measurements involved in the experiment were made. Under each of the seven conditions of retinal brightness differences, the subject was required to locate the oscillating target in both its near and far apparent positions, first when the fixation rod was moved away, and again when it was moved towards him. A total of six readings was made at each of the two positions for each of the given retinal brightness differences. A 3-minute period of light adaptation followed each increase in retinal brightness.

RESULTS AND DISCUSSION

Table I summarizes the experimental data obtained for subject A. H. at each of the six distances of observation (d). The seven differences in retinal illumination produced between the two eyes at each of the distances of observation are expressed as log (I_L/I_R), where I_L and I_R represent the retinal illumination of the left and right eye, respectively. The indicated values of log (I_L/I_R) are obtained by subtracting the optical density of each of the filters placed before the left eye (D_L) from the optical density of the filter retained before the right eye (D_R) [i.e., D_R—D_L = log I_L — log I_R = log (I_L/I_R)]. The apparent displacements of the oscillating target, measured from the plane of oscillation, are given (in centimeters) for both the near and far positions (C_N and C_F); each entry is the mean of six readings. The corresponding near and far latency differences (Δt_N and Δt_F), calculated from Equation [4], and their averaged values (Δt) are all expressed in milliseconds.[11]

[11] The required six values of 2b/V which were substituted in Equation [4] to calculate the magnitude of the latency differences (Δt_N and Δt_F) at each of the respective distances of observation are 0.655, 0.333, 0.251, 0.201, 0.168 and 0.134. These values are based upon the previously stated magnitudes of the linear velocity (V) and the corresponding distance between the principal points of the eyes (2b), existing at each of the distances of observation (d).

TABLE I

DISPLACEMENTS AND CALCULATED LATENCY DIFFERENCES PRODUCED BY DIFFERENCES IN RETINAL BRIGHTNESS AT SIX DISTANCES OF OBSERVATION

C_N and C_F* refer, respectively, to the near and far apparent displacements; each entry is based on the mean of six readings. Δt_N and Δt_F* are the corresponding near and far latency differences calculated from Equation [4]; the averaged values of Δt_N and Δt_F are given by Δt. The retinal brightness of the right eye is kept constant at 300 photons ($\log I_R = 2.478$).

Observation Distance	$\log I_L/I_R$	C_N (cm.)	C_F (cm.)	Δt_N (msec.)	Δt_F (msec.)	Δt (msec.)
30 cm.	0.10	0.135	0.058	2.96	1.26	2.11
	0.20	0.148	0.068	3.25	1.48	2.37
	0.50	0.290	0.197	6.39	4.27	5.33
	0.80	0.395	0.273	8.73	5.90	7.32
	1.00	0.488	0.302	10.83	6.52	8.68
	1.30	0.542	0.410	12.05	8.82	10.44
	1.50	0.627	0.422	13.98	9.08	11.53
60 cm.	0.10	0.533	—0.150	2.98	—0.83	1.08
	0.20	0.962	—0.130	5.42	—0.72	2.35
	0.50	1.188	0.542	6.72	2.98	4.85
	0.80	1.545	0.907	8.79	4.95	6.87
	1.00	.....	.....	.....	.....	.....
	1.30	2.222	1.420	12.80	7.69	10.25
	1.50	2.448	1.622	14.15	8.76	11.46
80 cm.	0.10	1.222	0.112	3.89	0.35	2.12
	0.20	1.333	0.053	4.24	0.17	2.21
	0.50	2.682	0.720	8.69	2.23	5.46
	0.80	3.057	1.332	9.95	4.10	7.03
	1.00	3.488	1.720	11.42	5.27	8.35
	1.30	3.773	2.017	12.40	6.16	9.28
	1.50	3.833	2.030	12.61	6.20	9.41
100 cm.	0.10	2.017	—0.130	4.14	—0.26	1.94
	0.20	2.413	0.167	4.97	0.33	2.65
	0.50	3.352	0.913	6.97	1.82	4.39
	0.80	4.327	2.077	9.09	4.09	6.59
	1.00	5.063	2.747	10.71	5.37	8.04
	1.30	5.902	3.185	12.60	6.20	9.40
	1.50	6.170	3.452	13.21	6.70	9.96
120 cm.	0.10	2.340	—0.527	3.34	—0.74	1.30
	0.20	2.797	—0.270	4.00	—0.38	1.81
	0.50	4.970	1.897	7.25	2.61	4.93
	0.80	6.233	2.845	9.19	3.88	6.54
	1.00	7.008	3.253	10.40	4.43	7.42
	1.30	8.498	5.290	12.78	7.08	9.93
	1.50	8.933	4.277	13.49	5.77	9.63
150 cm.	0.10	3.528	—1.977	3.24	—1.80	0.72
	0.20	4.232	—1.863	3.90	—1.69	1.11
	0.50	7.367	2.528	6.94	2.23	4.59
	0.80	9.765	3.635	9.36	3.18	6.27
	1.00	11.527	5.875	11.19	5.07	8.13
	1.30	13.227	6.632	13.00	5.69	9.35
	1.50	14.715	8.880	14.62	7.51	11.07

*The negative sign for values of C_F and Δt_F are used to indicate cases where the far position of the oscillating target lies closer to the subject than does the plane of oscillation.

LOCALIZATION ERROR. It is to be noted in Table I that several entries for C_F (and their corresponding Δt_F values) are preceded by a minus sign. The negative sign is used in all cases where the apparent far position of the oscillating target lies closer to the subject than does the true plane of oscillation. Such cases reflect the existence of a localization error. With filters of equal optical density (1.50) placed before each eye, the oscillating target appeared to move in a frontal plane which was localized by the subject, at each of the distances of observation, in a plane nearer than the plane defined by the true distance of the oscillating target. Consequently, when small differences in retinal illumination were produced between the two eyes, the resulting stereoeffects were of insufficient magnitude to locate the apparent far position of the oscillating target beyond the plane of oscillation. For A. H., the magnitude of the localization error (in centimeters) increases as the distance of the plane of oscillation increases. At the six observation distances used in the experiment, the amounts by which the true plane of oscillation appeared displaced in a direction towards the subject were: 0.016 cm., 0.350 cm., 0.648 cm., 0.913 cm., 1.259 cm., and 2.579 cm., respectively. [These displacements are equivalent to latency differences (obtained by substitution in Equation [4] and solving for Δt_N) of 0.35 msec., 1.95 msec., 2.05 msec., 1.85 msec., 1.78 msec., and 2.05 msec.; the displacements correspond to stereoscopic difference-angles of 24 sec., 132 sec., 139 sec., 125 sec., 121 sec., and 139 sec.].

The reason for the localization error has not been established. In the previous experiment reported by Lit, in which A. H. acted as one of the subjects, a localization error of comparable magnitude and direction was obtained. A separate investigation is being planned to determine the stimulus factors which influence its magnitude and direction. Fortunately, the localization error for A. H. is of sufficiently small magnitude as not to obscure the relationships under major consideration in the present investigation.

The data given in Table I are graphically presented in Figures 4 to 7. The curves drawn through the points have been fitted by visual inspection.

(1) Displacement. Figures 4 and 5 show the respective effects of (a) retinal illumination, log (I_L/I_R) and (b) observation distance, d, upon the magnitude of the near and far displacements (C_N and C_F).

(a) Displacement as a function of log (I_L/I_R). Figure 4 shows the relation-

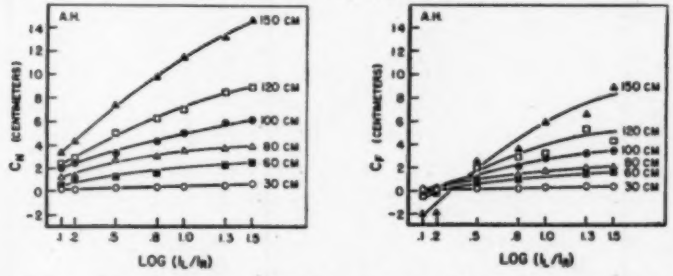

Fig. 4. Displacement as a Function of log (I_L/I_R). The near and far displacements (C_N and C_F) produced by the respective values of log (I_L/I_R) are given for each of the distances of observation indicated by the number accompanying the curve. Each point is the mean of six readings, and the curves drawn through the points have been fitted by visual inspection. Negative values of C_F indicate that the apparent far position of the oscillating target lies closer to the subject than does the true plane of oscillation, an effect which is produced by a localization error which is present when the oscillating target is observed under conditions of equal retinal illumination.

ship obtained between near and far displacements (C_N and C_F) and log (I_L/I_R). The number accompanying each curve represents the distance of observation, d, expressed in centimeters.

The relationship existing between displacement and log (I_L/I_R) may be characterized by the following general observations: (a) both C_N and C_F increase as log (I_L/I_R) increases; (b) the rate of increase is not the same for each of the curves; slope increases as distance of observation increases; (c) for a given value of log (I_L/I_R), both C_N and C_F increase progressively as the distance of observation is increased; (d) for a given magnitude of C_N or C_F, the value of log (I_L/I_R) necessary to produce the given displacement becomes progressively smaller as the distance of observation is progressively decreased.

The results described above are qualitatively consistent with the theory and geometric analysis of the Pulfrich stereophenomenon discussed in earlier sections of this paper. However, a minor deviation from theoretical predictions is to be noted. For a given value of log (I_L/I_R), produced at any given distance of observation, the magnitude of C_N is greater than the corresponding value of C_F, particularly for the greater distances of observation. This result duplicates the findings obtained by Lit in the previous experiment with A. H. acting as subject. Additional study is required to account for the persistent relative foreshortening of the far displacement with respect to the near displacement.

(b) Displacement as a function of d. Figure 5 shows the results obtained between near and far displacements (C_N and C_F) and distance of observation (d). The number accompanying each curve represents the value of log (I_L/I_R) holding for that curve. The figure is given to demonstrate more directly (a) that for any given value of log (I_L/I_R), both C_N and C_F increase as the distance of observation increases, and (b) that the rate of increase is not the same for all curves; slope increases as log (I_L/I_R) increases. The above statements are entirely consistent with predictions derived from the geometric analysis of the Pulfrich effect. Slight discrepancies with respect to C_F are to be noted for the two lowest curves of log (I_L/I_R).

(2) Latency Difference. Figures 6 and 7 show the respective effects of (a) retinal illumination, log (I_L/I_R) and (b) observation distance, d, upon the magnitude of Δt_N, Δt_F and Δt. Δt_N and Δt_F were computed from Equation [4] for each of the corresponding values of

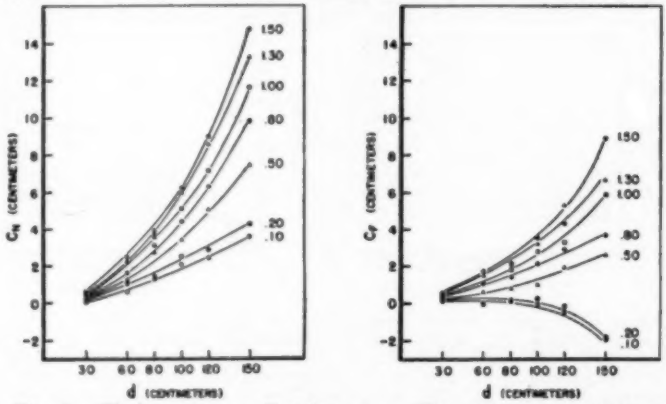

Fig. 5. Displacement as a Function of d. The near and far displacements (C_N and C_F) obtained at each of the distances of observation (d) are given with log (I_L/I_R) as parameter. The number accompanying each curve represents the value of log (I_L/I_R) holding for that curve.

C_N and C_F; each point on the curves is based upon the mean of 6 readings. The points for Δt represent the averaged values of Δt_N and Δt_F and are each based on a total of 12 readings.

(a) Latency difference as a function of log (I_L/I_R). Figure 6 shows the relationship between the calculated values of ΔtN. ΔtF and Δt and log (I_L/I_R) obtained at each of the distances of observation indicated by the number accompanying the curves.

The obtained curves indicate that both ΔtN and ΔtF (as well as their averaged values, Δt) progressively increase as the value of log (I_L/I_R) increases. This result is similar to the relationship obtained between C_N and C_F and log (I_L/I_R). How-

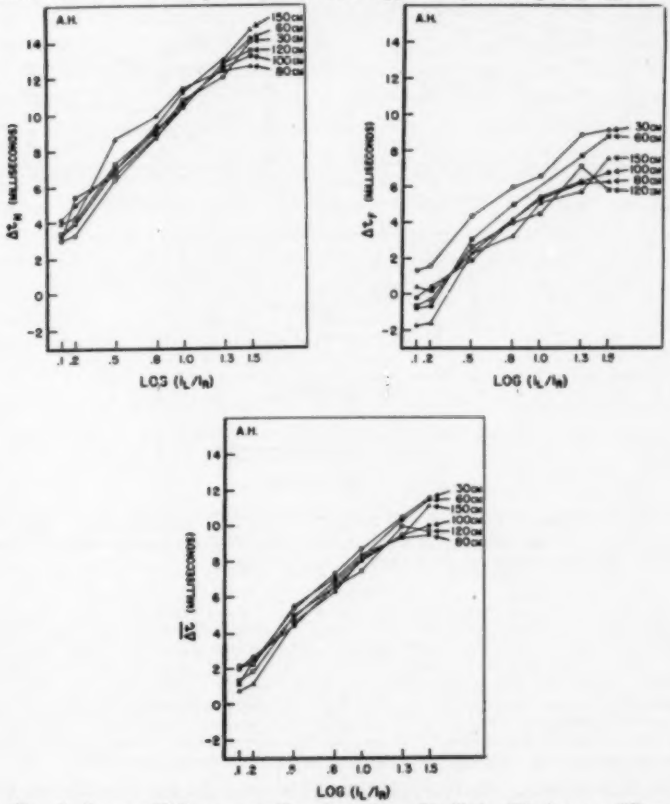

Fig. 6. Latency Difference as a Function of log (I_L/I_R). The latency differences (ΔtN and ΔtF) were computed from Equation [4] for each of the corresponding values of C_N and C_F produced by the respective values of log (I_L/I_R); each point is based upon the mean of six readings. The values of Δt represent the averaged values of ΔtN and ΔtF. The minus sign is retained when calculating ΔtF for negative values of C_F.

ever, for the case of either Δt_N, Δt_F or Δt, the rate of increase with log (I_L/I_R) appears to be the same for all distances of observation. Furthermore, with the exception of two curves at Δt_F (at the 30 cm. and 60 cm. testing distance) there is no evidence of a tendency for the curves to separate according to the respective value of the distance of observation. The curves representing values of Δt show considerable overlapping and are all confined within a narrow band whose range does not exceed two milliseconds for all but one of the given values of log (I_L/I_R). These results are in complete *quantitative* agreement with the geometrical analysis of the Pulfrich stereophenomenon.

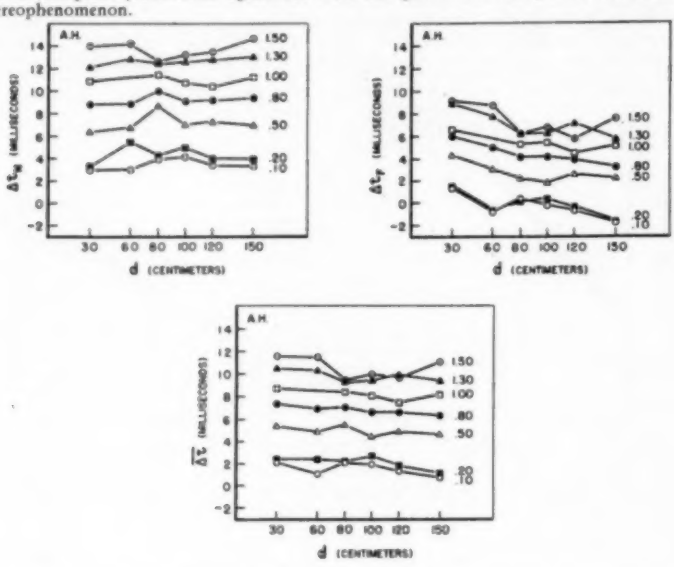

Fig. 7. Latency Difference as a Function of d. The calculated latency differences (Δt_N, Δt_F and Δt) obtained at each of the distances of observation (d) are shown for the respective values of the parameter, log (I_L/I_R).

(b) Latency difference as a function of d. A more direct demonstration of the independence of distance of observation upon the magnitude of the calculated latency differences may be obtained from Figure 7. The latency differences (Δt_N, Δt_F and Δt) obtained for each of the respective values of log (I_L/I_R) are given as functions of the distance of observation. It is to be particularly noted that, for any given intensity difference, expressed as log (I_L/I_R), the calculated values of Δt_N, Δt_F and Δt remain essentially constant for all observation distances. The tendency of the curves for Δt_F to deviate slightly from a horizontal line may represent variability of response. Further work with additional subjects is required for complete analysis.

In summary, the basic results of the present investigation are consistent with those predicted from the theory and geometric analysis of the Pulfrich stereophenomenon. It is demonstrated in accordance with theory that, for a given difference in retinal brightness, the magnitude of the stereoeffect varies with distance of observation to produce a con-

stant calculated latency difference. The magnitude of the constant latency difference increases as the intensity difference between the two eyes increases, and at a rate which probably depends upon the relationship which exists between the *absolute* visual latent period and level of illumination. The influence of accommodation, convergence and other factors associated with changes in observation distance do not appear to have any markedly disturbing effects upon settings made under the conditions of the present experiment. The agreement found between theoretical and experimental results serves to confirm the validity of the geometric assumptions underlying the theory of the Pulfrich phenomenon. Latency difference measurements obtained at distances of observation lying within the limits described in the present experiment, and resulting from any given difference in retinal illumination, may be considered replications: the obtained latency differences for the various distances of observation may be combined into a single statistical measure of central tendency with respect to the given difference in retinal illumination. It is anticipated that the minor discrepancies observed between theoretical and experimental results will become clarified as data from additional subjects become available for each of the variables described in the proposed research program.

SUMMARY

(1) The present experiment is concerned with a stereoscopic effect first described and analyzed by Pulfrich: an oscillating target appears to rotate out of its plane of oscillation when binocularly observed under conditions of unequal retinal illumination. The oscillating target appears nearer than it really is for one direction of stroke and farther than it really is for the return stroke. The apparent displacements are attributed to differences in the visual latent periods for the two eyes resulting from the differential retinal illumination. Geometric analysis of the theory of the Pulfrich effect allows for calculation of the corresponding latency differences when the near and far displacements in the vertical median plane are determined experimentally.

(2) The magnitudes of the apparent near and far displacements (C_N and C_F) and the corresponding latency differences (Δt_N and Δt_F), produced by differences in retinal illumination [expressed as log (I_L/I_R)], are measured as a function of the distance of the oscillating target from the subject's eyes. Data are obtained for seven differences in retinal illumination between the two eyes produced at each of six distances of observation (d) ranging from 30 cm. to 150 cm.

(3) The apparatus used to obtain the data is described. It provides for an oscillating target which is free to execute constant linear

motion in a frontal plane at any specified distance from the subject. The magnitude of the linear velocity varies with distance from the subject, but its angular velocity (18.91° per sec.) remains identical for all target distances. The angular extent of stroke of the oscillating target (20.5° of visual angle) and the angular size of the oscillating target (8.7 min. of arc) are maintained constant for all distances of observation. The angular extent of the rectangular field of view (21.6° x 4.2°) remains constant at all observation distances.

(4) The obtained experimental results are consistent with those predicted from the theory and geometric analysis of the Pulfrich stereophenomenon: for any of the given differences in retinal brightness, the magnitude of the stereoeffect varies with distance of observation to produce a constant calculated latency difference. Minor discrepencies between theoretical and experimental results are discussed.

(5) A program of research is proposed, designed to determine the influence of several basic stimulus variables upon the magnitude of the stereoeffect. In addition to providing data for theories concerned with some of the most basic visual processes, the results of the proposed research program should offer many useful clinical and industrial applications.

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THE RELATIONSHIP OF RETINAL RIVALRY TO READING ACHIEVEMENT*

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A review of the literature on retinal rivalry, or reciprocal replacement, impresses one with the scarcity of reliable data which have been used to support contradictory and in many instances erroneous claims. Attempts have been made to show its relationship to various processes and conditions such as physiological and psychological functions, age, sex, personality, and various components of the visual process using a variety of instruments and targets under many conditions.

Claims have been made that the ability to control rivalry is correlated with a high stereo-performance, although explanations are lacking. It is conceivable that the same sort of skill involved in switching seeing from one eye to the other might be helpful in controlling the position of focus of the eye to provide the maximum performance so far as stereopsis is concerned. It is possible then that the ability to control rate of rivalry might be correlated with reading ability. If the rate is subject to control or training two investigations are indicated:

a. Comparison of the difference between the maximum rate and the minimum rate with reading achievement.
b. Comparison of the passive retinal rivalry rate with reading achievement.

One phase of this study is concerned with whether there is a significant change in rivalry rate when there is a significant change in reading achievement following an intensive course in reading remediation and enhancement. The hypothesis to be tested is whether there is a positive correlation between the passive rivalry rate and the status of reading achievement.

OBSERVERS AND CONDITIONS

A group of 30 adults composed of executives and office personnel of the Illinois Central Railroad in Chicago volunteered for a three-month

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reading remediation and enhancement course offered by the remedial reading clinic of the Chicago College of Optometry. The first two sessions were devoted to an exhaustive battery of tests to determine the exact status of each individual in respect to the others of the group in terms of reading achievement. During this first week the retinal rivalry rates, percentage of fusion and percentage of stereopsis were also determined.

The members of the class received eight weeks of guided reading training. The class was divided into two groups of 15 individuals each. One of the groups received training once a week, three hours each session. The second group received two two-hour sessions per week for 7½ weeks. The two groups received 24 and 30 hours of training respectively.

Although a part of each session was devoted to individual training on certain aspects of the general performance, much of the work was done as group training. At least one short test was administered each session to determine progress. After the final training session had been completed, a "B" form of the original battery of tests was administered to determine the status of each individual. This also permitted the all important comparison of "before and after training" to determine whether any gain was significant. During the last week the rivalry, fusion and stereopsis were measured again.

All the reading tests, evaluations, and training procedures were carried out by the Director of the Remedial Reading Clinic, a trained remedial reading teacher.* No attempt was made to consider the visual status or refractive condition of the observers. No basic visual training was instituted and rivalry rate was not trained. The data of all tests presented in this paper were evaluated by the research department of Chicago College of Optometry.

SPECIFIC PROCEDURE

The battery of tests for reading achievement included the S. R. A. (Silent Reading Achievement) test which measures 10 reading skills. This test designed for adults, tends to equalize any particular advantages possessed by individuals, and the final score is based on rate of reading, general comprehension, paragraph meaning, directory meaning, map-table-graph reading, reading advertising material, index usage, technical vocabulary, sentence meaning and general vocabulary. Other tests used to give complete information dealt with speed of comprehension, level of comprehension, other vocabulary tests, speed of silent reading, oral

*Dorothy S. Orent, M. A. in Remedial Reading.

reading, span of recognition and ophthalmographic data on eye movements, comprehension of material, fixation and regressions for 100 words, words per minute and duration of each fixation.

In taking the rivalry rates the Keystone telebinocular was used with the transilluminated slide V. O. 15 composed of black diagonal lines. The observer was briefed until he recognized the phenomenon. The rate was recorded by the patient using a hand-counter, during an interval of one minute measured by the experimenter using a stopwatch. There was some apprehension that when the test was repeated in 10 weeks there might be an increase due to a "conditioned observer." The test was therefore repeated two more times at the same sitting allowing a one-minute rest between measurements.

The following week the observers began their reading enhancement training. Each standardized session consisted of 20 minutes each spent on tachistoscopic exposures; Harvard reading films and answering comprehensive questions based on the film; reading material on the reading rate controller using Strang's "Study Type of Reading Exercise," and answering 10 multiple choice questions on the subject. The final 30 minutes were devoted to comprehensive studies of material designed to develop broader recognition of central thoughts, definitions of new words, acquisition of a larger vocabulary and a search for information.

During the final week the same comprehensive battery of tests was conducted as initially for purposes of comparison. During this week the rivalry rates were measured in the same manner as described, three one-minute measurements with a one minute rest in between.

The data of this study must be analyzed with three considerations in mind:

a. Was there a significant change in reading achievement?
b. Was there a significant change in rivalry rate?
c. Was there any correlation between reading achievement and rivalry rate?

READING ACHIEVEMENT

This capacity was evaluated on the basis of the S. R. A. and E. R. R. tests. The E. R. R. is the effective reading rate, obtained by multiplying the actual reading rate by the percentage of comprehension expressed as a fraction. In both cases there was a marked increase of 17 per cent and 110 per cent respectively. Statistical evaluation (Chart 1) of these tests before and after remedial training shows that the increase in performance in both tests is highly significant. The critical ratio for this number of patients is 2.76 at the 1 per cent level, and the calculated

values are 11.95 and 12.16—both highly significant.

CHART 1.

	Mean	σ	σM	C. R. = 2.76 1% level
S. R. A.	105.52	17.7	3.35	11.95
	123.69	15.7	2.97	
E. R. R.	198.06	49.31	8.85	12.16
	405.28	106.40	19.10	

These calculated averages generally mean little unless the relative positions of the individuals remain approximately the same. Chart 2 shows this relationship in terms of correlation with significance of correlation (r) as .463 calculated in terms of t as 2.76.

CHART 2.

Correlation of		r = .463 1% level	t = 2.76 1% level
Original S. R. A.	Final S. R. A.	.89	10.11
Original E. R. R.	Final E. R. R.	.47	2.82
Original S. R. A.	Original E. R. R.	.64	4.30
Final S. R. A.	Final E. R. R.	.58	3.68

These findings show a positive degree of correlation which is significant at the 1 per cent level. It should also be noted that there is a positive correlation between the original S. R. A. and E. R. R. and the final S. R. A. and E. R. R. findings. In summary, the supervised remedial training resulted in an enhanced reading achievement by both criteria with a significant degree of correlation.

RETINAL RIVALRY

The three retinal rivalry findings taken before and after the training were averaged for each person. Before training began the calculated average for all the cases was 31.30 changes per minute (Chart 3), and after training the average rate was 34.37.

CHART 3.

	Mean R. R.	σ	σM	r = .487 1% level	t = 2.78 1% level
Before	31.30	12.74	2.5	.715	1.53
After	34.37	14.70	2.88		

Although the difference between the means is 3.07 changes per minute (1.54 cycles per minute) and even though the correlation is significant (each subject maintaining his relative position) a comparison

of these means shows essentially no significant difference in the two sets of findings even at the 5 per cent level.

RELATIONSHIP OF READING ACHIEVEMENT AND RIVALRY

Since the rivalry readings were taken at the same time as the S. R. A. and E. R. R. tests an analysis was made to determine what correlation existed between them. Chart 4 shows that the only significant relationship between these two performances was obtained on the E. R. R. after the period of training.

CHART 4.

	Before Training	After Training
S. R. A.	.47	.25
E. R. R.	.18	.93

$r = .463$, 1% level.

It might be argued that if the group were divided into an upper and lower half on the basis of the S. R. A. or E. R. R. tests that those in the upper half might show a positive correlation with rivalry rate. This relationship is shown in chart 5. Similarly, one could argue that if the group were divided into an upper and lower half on the basis of rivalry rate, that those individuals with higher rivalry rate scores would show a positive correlation with reading achievement. This comparison is shown in Chart 6.

In Chart 5 the members were grouped into an upper (high) and lower (low) group on the basis of the S. R. A. scores. No correlation with rivalry was found in either group.

CHART 5.

Correlation of S. R. A. and E. R. R. with Rivalry.

S. R. A. before training.	High	.24
	Low	.15
S. R. A. after training.	High	.16
	Low	—.08
E. R. R. before training.	High	.28
	Low	.39
E. R. R. after training.	High	.10
	Low	.05

The values of .24 and .15 respectively are far below the 5 per cent level of significance which is .553 for a group of this size.

A similar analysis of the data based on the S. R. A. test after training had been completed, also shows an absence of significance. Similar comparisons made for the E. R. R. before and after training shows no correlation.

Chart 6 shows the correlation figures when the group was divided

on the basis of rivalry rate and compared to the two reading achievement tests. Of the eight evaluations a positive and significant correlation was obtained on the S. R. A. test after training.

CHART 6.

Correlation of Rivalry with:	High R.R.	Low R.R.
S. R. A. before training.	.53	.46
S. R. A. after training.	.70	.05
E. R. R. before training.	—.18	—.26
E. R. R. after training.	.11	.33

5% level = .553

On the basis of this analysis it may be concluded that there was no significant correlation between rivalry and any reading performance regardless of the manner by which the comparison was made. The single exception of .70 out of 16 comparisons is obviously due to chance factors.

Although there is a lack of correlation, we still must determine whether individuals with low rivalry rates are substandard in their reading performance as compared to those with high rivalry rates.

The complete comparison of these performances is shown in Chart 7. For example, in the first part the records of the S. R. A. are separated into two groups on the basis of high and low rivalry rates. The mean scores for the S. R. A. were found to be 113 and 103 respectively. The difference of 10 points was not significant statistically as the critical ratio was found to be 1.85 (significance at the 5 per cent level begins at 2.18).

CHART 7.

	R. R.	Reading Mean	σ	σM	C. R. 5% = 2.18
S. R. A. before training.	High	113	10.63	3.36	
					1.85
	Low	103	14.63	4.22	
S. R. A. after training.	High	127	18.10	5.45	
					.44
	Low	124	12.80	4.04	
E. R. R. before training.	High	215	50.30	14.5	
					1.41
	Low	174	87.50	25.3	
E. R. R. after training.	High	453	85.00	25.6	
					.68
	Low	382	69.50	20.9	

After training, the group was again divided on the same basis. The group with high rivalry rates scored 127 as against 124 scored by

the group with lower rivalry rates. The critical ratio of .44 was far below the level of significance.

Similar treatment of the data using the E. R. R. shows parallel results. In no case was there a significant difference. The conclusion based on this record is that individuals with low rivalry rates perform as well on reading tests as those with high rivalry rates.

Although there is essentially no difference between the reading performances of individuals with high rivalry rates as compared to those with low rates a final comparison must be made in order to complete this study. If the group is divided into an upper and lower half on the basis of performance on each test are the differences in rivalry rate significant? In other words, do better readers (as judged by these tests) have significantly higher rivalry rates than poorer readers?

The answer to this question is found in Chart 8. In the first instance before training the group was divided into an upper and lower half on the basis of the S. R. A. test. The mean rivalry rates of these two groups are 35.9 and 24.4, respectively. The critical ratio of this difference is found to be 2.74 and not significant at the 1 per cent level.

CHART 8.

	Reading Group	R. R. Mean	σ	σM	C. R. 1% = 3.06
S. R. A. before training.	High	35.9	10.63	3.07	
					2.74
	Low	24.4	8.89	2.82	
S. R. A. after training.	High	41.3	16.49	4.75	
					2.43
	Low	28.0	9.00	2.59	
E. R. R. before training.	High	42.5	13.78	3.97	
					3.04
	Low	27.0	10.95	3.16	
E. R. R. after training.	High	29.8	10.86	3.12	
					.17
	Low	30.4	7.60	2.19	

After training the mean rivalry rates were found to be 41.3 and 28.0 respectively with the group divided on the basis of S. R. A. scores. The critical ratio is 2.43, below the level of significance.

Similar evaluation of the rivalry means in the high and low groups, prior to and after training as divided on the basis of E. R. R. performance shows no significant difference at the 1 per cent level. On this basis it must be assumed that there is no significant difference in the rivalry rates of good or poor readers.

CONCLUSIONS

Under the conditions of this experiment it may be concluded that:

1. There was a significant change in reading achievement as judged by the S. R. A. and E. R. R. tests, probably due to the reading enhancement program.

2. There was a statistically significant correlation in all the S. R. A. and E. R. R. comparisons—that is, the individuals, in general, tended to maintain their same relative position in the group on either test before and after training.

3. A positive correlation was found between retinal rivalry before training and after training.

4. There was no significant change in rivalry rate after reading training.

5. There is no consistent correlation between retinal rivalry and reading achievement regardless of how the comparisons are made.

6. When the groups were divided into upper and lower halves on the basis of S. R. A. and E. R. R.:

a. There was no significant correlation with rivalry in any group.
b. There was no relationship between achievement and rivalry, since the rivalry rates are essentially the same in both good and poor readers.

7. When the groups were divided into upper and lower halves on the basis of rivalry rates:

a. There was no consistent correlation in either group, and
b. there is no relationship between retinal rivalry and reading achievement, since individuals with low rivalry rates scored as well in terms of reading achievement as those who had high rates.

8. The final conclusion based on, and subject to the limitations of this study, is that there is no significant relationship between rivalry rate and reading achievement: that both functions seem to be independent variables occurring incidentally within the confines of the so-called visual functions.

LIMITATIONS AND IMPLICATIONS:

1. This study was based on small numbers, only 30 subjects being used. Some of the comparisons made were based on only 13 cases in each group.

2. A study should be made wherein a group of individuals are tested exhaustively before and after intensive retinal rivalry training to determine whether reading achievement changes as a result of rivalry training.

3. The implication of this study is that a change in rivalry rate, normally or through training, has no effect on reading performance.

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INTERPROFESSIONAL COOPERATION

Professional leaders in optometry and ophthalmology agree that the service supplied the public by both groups would be improved by closer professional clinical consultation between optometrists and ophthalmologists. This cooperation, to be of the greatest value to the patient, must come at the individual patient level.

Today, proper professional consultation exists between many individual practitioners, but certainly not for all. Interorganizational cooperation exists at the top association level through the National Interprofessional Committee on Eye Care. Through this committee representatives of all leading optometric and ophthalmological organizations confer on mutual problems.

One of the immediate problems of both groups is to bring the

consultative aspect of interprofessional relationship between optometrists and ophthalmologists into sharper focus in those areas where it is not functioning today. The best interests of the patient require this action. This is being helped to some extent by the formation of interprofessional committees at State levels.

The major causes of friction which have prevented closer working relationships in the past have been removed to a great extent and those that remain are minor enough to be overlooked or readily eliminated by more objective thinking and action on the part of all concerned in both groups. If the time spent ironing out these insignificant differences were spent on developing a program of cooperation between the two groups, patients would benefit immeasurably.

What are these minor causes of friction? There are many, but two recent examples come to mind.

Not long ago, a medical editor permitted the publication of an article in which optometrists and opticians were described as doing similar and relatively unimportant technical work. The refractive work of the optometrist was not mentioned. This aroused the indignation of many optometrists who pointed out that their professional standing was undetermined by such comment. The editor may have corrected the error, but much unnecessary friction was caused between the groups as a result of the article, and much energy is wasted in straightening out ill feeling.

On another recent occasion, an independent optometric editor of a sectional publication demanded that ophthalmology withdraw from the field of refraction. This article—unauthorized by any national optometric association—aroused indignation among many ophthalmologists who claimed they were being improperly attacked.

Such are the trivia that keep optometry and ophthalmology apart.

The above incidents happened to occur at the national level. Similar examples could be presented which occurred at the local level. Most are minor and of little or no significance, as a little analysis of the two examples will show.

In the manuscript in which optometry and opticianry were lumped together and considered of little consequence, the author may or may not have intended a deliberate slur. The refractive aspects of optometry were ignored, but as most optometrists supply material for their patients, some of their work is similar in nature to that of the dispensing optician. In addition, many optometrists and particularly those with offices on the street level in metropolitan centers, still fill prescriptions for glasses

written by ophthalmologists. In doing this they are invading the field of opticianry, and to make the matter worse, are ignoring the minimum standard of optometric practice as approved and adopted by the American Optometric Association and the Academy. These things being true, there certainly was an element of confusion in all of this for the author mentioned, although a little study on his part would have helped clarify the matter. At best it was very careless writing. On the other hand, it behooves optometry to divorce itself from any but its own dispensing if it wishes to avoid the inference that its practitioners are opticians in fact if not in name.

In the second case mentioned, that of having ophthalmology withdraw from refraction, the suggestion is so absurd that it has never been given any thought or consideration in official optometric circles at the national level. Ophthalmology must refract its pathological cases to determine whether surgery or therapeutic care has been beneficial. In cases undergoing treatment, a periodic refraction is a diagnostic tool of great value as it supplies many of the yardsticks used to measure the progress of the cure. There is no thought on the part of organized optometry of having ophthalmology stop this work, nor is it the prerogative of optometry to even consider this matter. Refraction is an essential tool in the practice of both optometry and ophthalmology.

Naturally, situations are bound to arise in the field of eye care at both the national and local levels which may prove irritating to either optometry or to ophthalmology. There are 25,000 individuals involved, and some tempers are short. Occasionally practitioners take advantage of each another. As the two groups draw closer together, however, irritating problems are less likely to occur. Along this line of minimizing the problems, the two groups have, through the National Interprofessional Committee on Eye Care, approved a plan for more effective consultation in referred cases wherein refractive findings will be returned confidentially to the referring optometrist for his future evaluation in his final refraction of the case. This will do much in bringing the practitioners together.

The more conservative men in each group must be relied upon to minimize the differences and to overcome the problems as they arise. This is no time to rock the boat. The public has become decidedly eye conscious, and is less and less disposed to tolerate mediocre service dressed in the shabby clothing of professional jealousies. Interprofessional wrangling is a sure way to hasten the day of socialized health care with all its inherent drawbacks. There is enough constructive work for

optometry and ophthalmology and offensive or inflammatory attacks by one group on another do nothing but harm, which in turn is passed on to the patient in the long run.

Today there is little of essential nature standing in the way of fine cooperation between professional optometry and ophthalmology. Both medicine and optometry are on record favoring this cooperation in the public interest. Let us work together towards that goal.

CAREL C. KOCH.

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

PROGRAM FOR ANNUAL MEETING AMERICAN ACADEMY OF OPTOMETRY

Hotel New Yorker

New York, New York

December 8, 9, 10, 11, 1951

The Papers and Program Committee of the American Academy of Optometry presents the following program for the coming annual meeting at the Hotel New Yorker, New York City, December 8 through 11. Committee members responsible for this outstanding program are as follows: Dr. Meredith W. Morgan, Jr., Berkeley, California, Program and Papers Committee chairman; Dr. I. M. Borish, Kokomo, Indiana; Dr. Isidore Finkelstein, New York City; Dr. Henry W. Hofstetter, Los Angeles, California, and Dr. F. W. Sinn, Philadelphia, Pennsylvania.

Papers to be presented at the section meetings will be announced at the annual meeting, according to section chairmen. These section meetings will be in charge of the following Academy members: Aniseikonia, Dr. Leo Madigan, Boston, Massachusetts; contact lenses, Dr. John C. Neill, Philadelphia, Pennsylvania; occupational vision, Dr. Richard Feinberg, Chicago, Illinois; orthoptics, Dr. J. Donald Kratz, Souderton, Pennsylvania.

The orthoptics section has tentatively announced that their Sunday morning meeting will be at Columbia University. A talk by Dr. Max Schapero of the Los Angeles College of Optometry on "A

Comparison of Some Theories of Squint Treatment," is scheduled for Monday morning, and the Tuesday meeting will be announced. There is a possibility case reports will be given Tuesday by members of the section, according to Dr. Kratz.

Special attention is called to the significance of the annual round table banquet speech. Dr. Rudolph Ehrenberg, chairman of the recently organized National Board in Optometry, will cover the purposes, functions and progress of this highly important organization. This is the first "progress" report, and should be of interest to every member.

Another highlight of the meeting will be the Sunday afternoon sessions which will be held at the School of Optometry, Columbia University. Here Academy members will be the guests of Professor C. L. Treleaven, and his excellent faculty staff. At this afternoon session, a number of the faculty will present original papers. The detailed program of these papers will be presented at the school.

SATURDAY, DECEMBER 8, 1951

9:00-10:00 A.M. ..... Registration

10:00-11:00 A.M. ..... Business Session

11:00 A.M. ..... Pathology Section

"Biomicroscopy of Certain Corneal Disturbances." William G. Walton, Jr., O.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Noon ..... Lunch

1:30 P.M. ..... Lecture

"Color Vision Differences in the Two Eyes of a Given Individual," Henry Knoll, Ph.D., Los Angeles College of Optometry, Los Angeles, California.

2:15 P.M. ..... Lecture

"The Effect of Aniseikonia on the Amplitude of Vertical Fusion," Vincent Ellerbrock, Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio.

3:00 P.M. ..... Lecture

"Variation of Refractive Status With Menses." Dorothy Bergin, O.D., Los Angeles College of Optometry, Los Angeles, California.

3:45 P.M. ..... Lecture

"The Patient as a Person. Symptoms and Case History," Robert Bannon, O.D., D.O.S., Bureau of Visual Science, American Optical Company, Southbridge Massachusetts.

4:30 P.M. ..... Lecture

"Summation Effects in Scatter and Diffraction Kinetics of the Cornea." Isidore Finkelstein, Ph.D., School of Optometry, Columbia University, New York, New York.

6:00 P.M. ..... Dinner

8:00 P.M. ..... Lecture

"Scope and Significance of the Accommodative Unit." Joseph Pascal, O.D., M.A., M.D., New York, New York.

8:45 P.M. ..... Lecture

"A Further Investigation of Accommodation and Con-

vergence in a Patient With Adies' Pupil." Robert Harrigan, O.D., School of Optometry, University of California, Berkeley, California.

SUNDAY, DECEMBER 9, 1951

9:00-11:00 A.M. ..... Section Meetings
Aniseikonia, Contact Lenses, Orthoptics, Occupational Vision.

11:00 A.M. ..... Pathology Section
"Endocrine Disturbance and the Eyes," I. Kaplan, M.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Noon ..... Lunch

1:30-5:30 P.M. ..... Columbia University
Papers by members of faculty, School of Optometry, Columbia University.

6:00 P.M. ..... Dinner

8:00 P.M. ..... Lecture
"Dewey's Transactional Theory of Perception," Eugene Freeman, Ph.D., Chicago College of Optometry, Chicago, Illinois.

8:45 P.M. ..... Lecture
"Basic Clinical Considerations in Strabismus Orthoptics," William Smith, O.D., Massachusetts College of Optometry, Boston, Massachusetts.

MONDAY, DECEMBER 10, 1951

9:00 A.M. ..... Section Meetings
Aniseikonia, Contact Lenses, Orthoptics, Occupational Vision.

11:00 A.M. ..... Pathology Section
"Visual Fields," Part I. Harold Simmerman, O.D. Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Noon ..... Lunch

1:30 P.M. ..... Lecture
"A Survey on Myopia," Irving Vica, O.D., Albany, New York.

2:00 P.M. ..... Lecture
"The Existence of a Negative Accommodation in Certain Subjects," Yves Le Grand, translated by Lieutenant Colonel Elwin Marg, Ph.D., School of Optometry, University of California, Berkeley, California.

2:30 P.M. ..... Lecture
"The Changes in Refraction Between the Ages of 5 and 14, Theoretical and Practical Considerations," Monroe J. Hirsch, Ph.D., Los Angeles College of Optometry, Los Angeles, California.

3:00 P.M. ..... Lecture
"Negative Accommodation and 'Flashes' of Clear Vision," Lieutenant Colonel Elwin Marg, Ph.D., School of Optometry, University of California, Berkeley, California.

3:30 P.M. ..... Lecture
"Correlation Between Personality and Refractive Error," Max Schapero, O.D., Los Angeles College of Optometry, Los Angeles, California.

4:00 P.M. ..... Round Table Discussion
4:30 P.M. ..... Business Session
6:00 P.M. ..... Refreshments
7:00 P.M. ..... Annual Formal Banquet

Speaker—Rudolph H. Ehrenberg, O.D., Granite Falls, Minnesota, President, National Board of Examiners in Optometry. Topic, "The National Board of Optometry."

TUESDAY, DECEMBER 11, 1951

9:00-11:00 A.M. ..... Section Meetings

Aniseikonia, Contact Lenses, Orthoptics, Occupational Vision.

11:00 A.M. ..... Pathology Section

"Visual Fields," Part II. Harold Simmerman, O.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Noon ..... Chapter Luncheon

2:15 P.M. ..... Lecture

"Objective Determination of Visual Acuity on the Bases of the Optokinetic Nystagmus," William Schumann, O.D., Vineland, New Jersey.

3:00 P.M. ..... Lecture

"Positive Voluntary Accommodation," Thaddeus R. Murroughs, M.S., O.D., Northern Illinois College of Optometry, Chicago, Illinois.

3:45 P.M. ..... Lecture

"The Validity of Clinical Data, from Correlation Studies," Meredith W. Morgan, Jr., Ph.D., School of Optometry, University of California, Berkeley, California, and, "The Validity of Clinical Data, from Graphical Analysis," Henry W. Hofstetter, Ph.D., Los Angeles College of Optometry, Los Angeles, California.

4:30 P.M. ..... Lecture

"Visual Recognition," Carl F. Shepard, O.D., Northern Illinois College of Optometry, Chicago, Illinois.

5:15 P.M. ..... Closing Session

Brief synopsis of discussions at section meetings.

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

CAMPUS NEWS

Your reporter recently took a quick tour of our schools of optometry (by mail) to find out what's new in research, building projects, programs and staff membership. The deans were exceedingly busy getting Fall classes under way, but took time out to tell us what's new in their school.

COLUMBIA UNIVERSITY

At Columbia, the fifth year in their new five year program has been reached—72 students are working on their M.S. degree. According to Dr. C. L. Treleaven, the recently occupied seven-story building at 132 West 60th Street is "bursting at the seams with activity," and additional laboratories are being equipped in the adjacent University building at 15 Amsterdam Avenue, where optometry has taken over the third floor. The Columbia optometric staff now numbers nine full time, 13 nearly full time teachers, and 30 part-time clinicians. Several researches are under way by members of the staff, Dr. Treleaven tells us. Dr. Alfred Lit and Dr. Aaron Hyman are continuing their studies on the Pulfrich phenomena; Dr. Isidore Finkelstein is continuing work on certain problems of the physiology of the cornea relating to the wearing of contact lenses, partly on a grant-in-aid from the American Academy of Optometry; Dr. Daniel Woolf is doing research on the cytology of the ciliary muscle, partly on a grant-in-aid from the American Optometric Foundation. Other research now going on includes a study of corneal changes in certain types of myopes (Dr. Ernest Giglio); a project relating to the aberrational properties of ophthalmic lenses, (Dr. E. W. Bechtold); investigation of the problems related to the measurement and significance of aniseikonia, and research in retinal correspondence.

Dr. Treleaven also reports that an entirely new laboratory in visual perception is being developed by Professor Lit with the assistance of Professor Bechtold and Dr. Hyman. For the first time at Columbia School of Optometry, a dispensary is in operation.

A special feature of this year's curriculum at Columbia is a weekly colloquium for staff and senior students. The colloquium program includes special current case reports from their own laboratories, invited guest speakers and reports of current developments in the eye care field. According to school officials, this weekly program is proving a "powerful stimulus to the entire school in their pursuit of knowledge in the field of vision."

NORTHERN ILLINOIS COLLEGE OF OPTOMETRY

At Northern Illinois College of Optometry, recently appointed Dean Richard Feinberg is busy organizing the coming year's program, and will announce research projects, building plans, etc., at a later date In line with planned expansion, several new members have been added to the faculty. In addition to Dr. Thaddeus Murzoughs appointment as head of the new laboratory in binocular seeing reported last

month in the Journal. N. I. C. O. has the following new staffers: Phillip Gertler, B. S., Ph.D.; Frederick Samson, M. S.; N. M. Schlichenmayer, B.S., O.D.; and Fred B. Stern, B.A., all teaching physiology; T. G. Engelmann, B.S., M.S., instructor in general anatomy; and Norman Ginsburg, M.S., psychology. Drs. Randolph Sakada and O. M. Tobey are new on the clinic staff. At present, says Dr. Feinberg, the major research at N. I. C. O. is being conducted by Dr. Murroughs on strabismus, but other projects are now being planned. Student enrollment is on the upswing, although not as high as in post-war years. N. I. C. O. currently has 173 students, all sophomores and juniors.

LOS ANGELES COLLEGE OF OPTOMETRY

Los Angeles College of Optometry students recently had the privilege of hearing Swedish scientist, Dr. Ragnar Granit, speak on neurophysiology. Dr. Granit is director of the Nobel Institute of Neurophysiology of the Royal Caroline Institute, Stockholm, Sweden. He is also the author of "Sensory Mechanisms of the Retina" (1947), and more than 50 original papers on retinal functions.

PENNSYLVANIA STATE COLLEGE OF OPTOMETRY

Pennsylvania State College of Optometry students held their second annual building fund dance on November 2. Proceeds of the event, sponsored by Omega Delta fraternity, go to the College's new building fund.

CHICAGO COLLEGE OF OPTOMETRY

New faculty members at Chicago College of Optometry, Dr. Morton Abram, administrative vice president, tells us, are the following: Dr. Harry Pine, Chicago optometrist and former president, A. O. A., widely known for his lectures on practice building, ethics and economics. Dr. Stanley Dulsky, Ph.D., formerly clinical psychologist at the Rochester Guidance Center, Rochester, New York, has been appointed assistant professor of psychology. Dr. Erich W. Fantl, M.D., joins the staff as assistant professor of ocular pathology. Dr. Fantl formerly has been associated with the Illinois Eye Infirmary, and at present is also a staff member of Woodlawn Hospital and consultant in ophthalmology at Illinois Hospital School for Crippled Children. Dr. Jack Copeland, optometrist and technical consultant to the ophthalmic instrument department, Central Division, Bausch & Lomb Optical Company, will be a visiting lecturer at the college. Former instructor of anatomy at Marquette University, Salvatore DeSalva, M.S., has been appointed assistant professor of anatomy. And Dr. Raoul W. Sabatini,

Ph.D., will conduct research in the Institute for Advanced Reading as assistant professor of psychology. Dr. Sabatini formerly directed the remedial program at N. I. C. O.

SOUTHERN COLLEGE OF OPTOMETRY

Dean M. E. Broom of Southern College of Optometry reports that a recent graduate, Dr. E. W. Taylor, has been retained as a clinic staff member. Dr. Taylor also has opened a practice in Frayser, Tennessee. Also new on the clinic staff is Dr. George Hays, and Dr. C. H. Bennett, Ph.D. is now a member of the faculty, teaching biological science. Dr. Broom says the Fall freshman enrollment of 58 brings the enrollment total to 357.

UNIVERSITY OF CALIFORNIA

Dr. Frederick W. Hebbard, instructor in optometry, "reporting" for the School of Optometry, University of California, writes that out-of-state students might be interested in learning that registration limitations have recently been modified. Under the new program, more out-of-state students will be permitted to enter, provided, of course, they have satisfactorily completed pre-requisite work, and meet other entrance requirements.

Research under way at the University of California includes that of Dr. Gordon L. Walls, who has been doing extensive work on the problem of anomalous color vision; Dr. Robert F. Harrigan who, with Dr. Meredith W. Morgan, Jr., is studying the accommodation-convergence relationship; Dr. Frederick W. Hebbard, investigating the so-called physiological nystagmus, and Darrell B. Carter, a graduate student in physiological optics, who is working on the problem of visual dominance.

New faculty appointments at the University of California optometry school include John F. Regan, clinical instructor in optometry and Merton C. Flom, associate in optometry. Dr. Meredith W. Morgan, Jr. has been promoted to the rank of full professor and Dr. Elwin Marg, to assistant professor. Dr. Marg, a Lieutenant Colonel in the Air Force Reserve, is still on active duty at Wright Patterson Air Force Base, Dayton, Ohio.

PACIFIC UNIVERSITY

The College of Optometry at Pacific University expects its new optometry building to be completed on schedule in February, 1952. The new structure has been named Jefferson Hall in honor of Portland physician, Dr. G. Orlo Jefferson, who, upon his death two years ago,

left more than $90,000.00 for the plant. Total cost of the building is estimated at $150,000.00. The two-story steel structure will be used for both clinical and classroom work, and will house a model classroom and a specially-designed amphitheater for the pathology department.

MEETINGS—CURRENT AND FUTURE

Industrial lighting, color, safety and vision were the topics under discussion at the recent industrial vision short course at Louisiana State University. Leading optometrists and ophthalmologists as well as industrial specialists lectured at the meeting sponsored by the Louisiana Optometric Association. Speakers and their subjects were as follows: Dr. Joseph Tiffin, "Industrial Vision Tests and Testing," and "Pre-Employment, Job Placement and Visual Efficiency." Dr. Hedwig Kuhn, M.D., "Eye Care in Industry." Mr. L. M. Ketch, "Lighting in Industry." Dr. Carl F. Shepard, "Care of Vision in Industry." Mr. S. W. Quisenberry, (Dupont), "Sight, Success and Safety." Mr. E. W. Hoard, (Fulton Bag Company), "Setting Up an Industrial Vision Program," and "Production Gains, Employee Attitudes, and Accident Control."

Theme of the West Tennessee Optometric Association's fall lecture series was "Vision and the Child in West Tennessee." According to Dr. Irving Filderman, Memphis, program chairman, the series was planned to answer two questions: (1) What is the state of vision of children in West Tennessee and what professional services should be made available within our community to provide for prevention as well as the necessary daily care. (2) How can we organize our educational, optometric, and allied resources so that every child can be assured of an opportunity for proper growth and development. Answering these questions on the speaker's rostrum were Marshal D. Keith, O.D., J. Arthur Womble, O.D., Emmett G. Parham, O.D., and Irving Filderman, O.D.; Dr. Chester Pheiffer, Ph.D., and educators Lydia A. Duggins and Verna Vickery. Lectures were held during September, October and November.

The Northwest Congress of Optometry opens in Portland, Oregon, on December 16 this year, with speakers from the fields of optometry, medicine, psychology. Principal speaker will be Dr. John Paul Nafe, head of the department of psychology at Washington University. Other speakers are Dr. C. V. Lyons, San Francisco, Dr. J. L. Sears, faculty member, College of Optometry, Pacific University; Dr. Harold Haynes of the College, and Dr. A. M. Skeffington, executive director, Optometric Extension Program.

CALIFORNIA ACTIVITIES

News and more news about California optometric activities! Four California optometrists participated in the 1951 California Traffic Safety Conference as representatives of the California Optometric Association. The group attended the two-day conference at the request of Governor Earl Warren. Dr. Solon Braff, Oxnard; Dr. George I. Deane, Jr., Merced; Dr. Kenneth MacPherson, Stockton; Dr. Arthur J. Gay, Sacramento, and Paul Yarwood, executive secretary of the C. O. A., Sacramento, joined 500 other leaders in traffic safety in discussing problems in traffic and their solution.

Another Governor's conference in which C. O. A. members took part this Fall was on the problems of the aging. Dr. Joseph Ziff, Los Angeles, Dr. C. Roger Brissman, Ontario, and Mr. Yarwood attended the meeting where section discussions were held on the problems of California's elderly citizens.

Fresno State College, in cooperation with the Fresno city and county schools, and Fresno County Medical Society and the Central California Optometric Association, sponsored a Vision Conservation Institute October 24 and 25. The panel discussion on the relationship between the medical care program and the educational programs in the schools was listened to by leaders from the field of education, optometry, medicine and nursing. Dr. Franklin M. Foote, executive director of the National Society for the Prevention of Blindness, attended the conference. Dr. Max Blechman, Fresno, and Dr. Herbert Kallman, Fresno, represented optometry.

The alums of Los Angeles College of Optometry got together November 11 for their annual meeting. The day's activities included viewing scientific films, open house at the College, an educational session on optometric economics conducted by Dean Henry W. Hofstetter, a business meeting, and an annual banquet. Following the alumni association meeting, on November 12, an educational seminar was held at the College under the direction of the C. O. A. There were three speakers—Dr. Raphael Koff, M.D., "Recent Advances in Cortisone and ACTH Therapy as Applied to the Eye." Dr. Arthur L. Bietz, Ph.D., "Why Patients Act That Way." Dr. M. W. Nugent, M.D., "Fundus Manifestations in Systemic Disease."

BAUSCH & LOMB CELEBRATES 98TH BIRTHDAY

Ninety-eight years ago, two young men with high hopes and little money ($60.00) opened a small optical shop in downtown Rochester, New York. The tiny shop was a novelty to the town, with its

window display of horn-rimmed glasses, opera glasses and magnifiers, for this was the first optical shop in western New York.

The hopes of John Bausch and Henry Lomb were realized to a far greater degree than they probably dared dream, for from this modest beginning one of America's leading optical firms developed, with sales representatives in every principal city in the world, factories in Rochester and in Canada, Brazil and Wellsville, New York, and a production of millions of eyeglass lenses and frames annually.

John Bausch's craftsmanship with hard rubber eyeglass frames gave the infant firm its first major impetus, and his elder son, Edward, designed and manufactured microscopes which gave B & L distinction in this field. During the Spanish-American war, the firm produced the Navy's first telescopic sight, used by Admiral Dewey at Manila. Edward's younger brother, William, came into prominence in 1912 when he foresaw that war in Europe would cut off imports of optical glass from abroad—glass needed for ophthalmic lenses, binoculars, gunsights, submarine periscopes and other military products. After many months of trial and error experiments, he succeeded in 1915 in turning out the first pure melt of optical glass produced in America, which enabled B & L to meet demands for lenses and military optical equipment, and won for the firm the War Department's Distinguished Service Award. Equally distinguished was B & L's record in World War II.

Bausch & Lomb's record of achievement could be continued at much greater length and we regret space does not permit our telling more. Instead, we must say, "Happy Birthday," and look forward to celebrating their 100th anniversary in 1953 with more stories from their colorful history.

A NEW TREND IN EYE WEAR?

It has been quite awhile since we have commented much on fashion in eye wear—the once startling, but beautiful plastic frames with jewels, lace and gold trim are part of a woman's wardrobe now—but a prediction by Kono Manufacturing Company has caught our eye and set us to wondering if a new trend is on the way. "The lorgnette (says the Kono news release) . . . will be adopted this Fall as a smart utilitarian visual aid, designers predict. The baby folding lorgnette, as exemplified by Kono and worn by well groomed women, is invaluable for scanning menus, reading phone numbers, looking at play bills and reading where a regular mounting is not required. . . . Authorities believe that the increased acceptance of the lorgnette will remove all snob appeal from the saucy but constructive type of ophthalmic aid."

We'll be watching for the appearance of these lorgnettes which Kono is making in plastic with calico treatment, gold and semi-precious stone trim. It would be a very interesting fashion trend.

NEWS BRIEFS

Consultation problems between ophthalmologists and optometrists were the chief topic of discussion at the recent meeting of the National Interprofessional Committee on Eye Care in Chicago last month. The 12 man committee will meet next in New York City in December. . . . The Woman's Auxiliary to the American Optometric Association currently is campaigning nationally to promote subscriptions to *Visual Digest*. In charge of the project is Mrs. Bernard A. Commerce, Third Vice President of the Auxiliary. . . . Six Titmus Optical Company employees received gold watches for 25 years of service at a recent "old timer" banquet. Titmus now has 16 employees with more than 25 years service, 41 employees with more than 20 years service, 60 with 15, one 30-year and one 35-year employee. . . . A new pamphlet published by the National Society for the Prevention of Blindness explains how glaucoma can rob a person of sight, "without warning, without pain," and tells how blindness from glaucoma can be prevented, under certain circumstances. A thorough eye examination every two years is recommended. The pamphlet is available from the Society, 1790 Broadway, New York, New York. . . . Several prominent speakers will appear on the A. O. A.'s Public Relations Roundtable in New York in December: Dr. Lois Bing, Cleveland, Ohio; Dr. Kenneth H. MacPherson, Stockton, California; Dr. E. H. Westland, Ambridge, Pennsylvania; Dr. P. N. DeVere, Morgantown, North Carolina. The conference, at which both successful and unsuccessful public relations programs will be discussed, will be moderated by A. O. A.'s Public Relations Director, Dr. E. M. Soles. . . . Reuel A. Sherman, director of occupational vision at Bausch & Lomb Optical Company, a pioneer in the field of occupational vision, lectured to management, students, businessmen, and faculty members at the University of Chattanooga, October 26. The guest lecturer spoke on how vision affects employee earnings, safety, productivity and well being. . . . Dr. Ralph H. Green, Dean, Massachusetts College of Optometry, was the commencement speaker at Chicago College of Optometry's Fall graduation. Dr. Green advised graduates to "strive for proficiency in three fundamental doctrines," (1) sound preparation in the basic scientific philosophies of optometry; (2) learning to combine in proper proportion the science and art of optometry; (3) taking your rightful place in your com-

munity as a leader in public eye health. . . . The Better Vision Institute's 1952 program will be along similar lines as that of 1951, with perhaps more work in television, it was decided at the last quarterly meeting in New York. This means continuance of hard-hitting ads in national magazines, radio programs of the human-interest type, and specially prepared brochures for wide distribution to the public.

OPTOMETRISTS IN THE NEWS

Dr. William Smith, Boston, Massachusetts, has recently been appointed consultant in orthoptics for the division of maternal and child health of the Department of Health, Commonwealth of Massachusetts. The appointment was made at the recommendation of the head of the Child Growth and Development Department.

Dr. Franklin A. Seward, past president of the New York State Optometric Association, appeared on a New York TV program where he was interviewed about vision, sunglasses and visual training. The program emanated over the DuMont network in New York and appeared also in Philadelphia, Baltimore and Washington, D. C.

HELMHOLTZ VOLUMES WANTED

Looking for a set of Helmholtz's Physiological Optics (3 volumes) published by the Optical Society of America in 1925, is Dr. Phillip R. Haynes, a graduate student at The Ohio State University School of Optometry. Dr. Haynes wishes to buy the set and will appreciate hearing from anyone who might have one for sale.

BRITISH CHAPTER

The British Chapter of the American Academy of Optometry was host to overseas visitors of the International Optical Congress in July at a cocktail party held at the Naval and Military Club, Piccadilly. Arrangements chairman was Lord Charnwood. Representing the Academy for the United States was Dr. John C. Neill, Philadelphia, Pennsylvania. Chapter secretary Eric Bateman reports that nearly all members of the British chapter were present, and special guests, besides overseas delegates, were Lord and Lady Crook (Lord Crook is chairman of the inter-departmental committee considering optometric legislation for Britain), and Mr. Marton, chairman of the Congress.

On the Tuesday following the Congress, the first technical session of the chapter took place, with Lord Charnwood presenting a thoughtful and provoking paper on the shape of visual space and problems of stereopsis, as well as reviewing Congress papers on binocular vision.

OPTOMETRY MOURNS LOSS OF KRASKIN AND HAUS

Word has just reached the Academy office of the unexpected death of two well-known Academy members, Dr. Lewis Kraskin of Washington, D. C., and Dr. George J. Haus of Memphis, Tennessee.

Dr. Kraskin has been Secretary of the Board of Examiners in Optometry for Washington, D. C., for the past 25 years, and he has been very active in the orthoptic section of the Academy.

Dr. Haus was a faculty member of the Southern College of Optometry, Memphis. He was author of the text, "Ophthalmic Mechanics for the Refractionist." Both men will be missed by their many friends in the Academy and educational circles.

ANNOUNCEMENT

GRADUATE COURSE IN ANISEIKONIC WORK

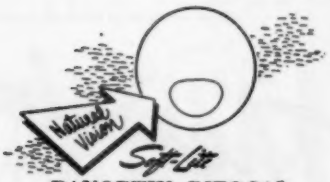
The Aniseikonic Forum announces that a three-day graduate seminar in the fundamentals of aniseikonia and the technique of space-eikonometry will be held at the School of Optometry, Columbia University, 132 West 60th Street, New York City, on December 5, 6 and 7, 1951.

The instructors for this three-day course will be Dr. Leo F. Madigan, Boston, Massachusetts, Dr. Harold M. Fisher, New York City, and Dr. Robert E. Bannon, Southbridge, Massachusetts. These men are all former associates of the Dartmouth Eye Institute of Hanover, New Hampshire, and all have had years of faculty and clinical experience in this work.

This short course will be limited to an enrollment of 12 optometrists. The fee for the course is $50.00. One-half of this sum is payable at once, and the remainder at the beginning of the course. Optometrists wishing to register should write to Dr. Robert E. Bannon, Secretary, The Aniseikonic Forum, Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts.

How To Eliminate "BIFOCAL NERVES"

With all the bifocals available today, good and bad, it must try prescribers' nerves to know which is best. Cost of refracting and adjusting *time* is as high in $$ for one bifocal as another. The Rx materials cost is a small percentage of the total fee. So it sifts down to determining which lens gives the best results in each case. Recommending modern Soft-Lite Panoptik Bifocals and Trifocals, with improvements made possible by Bausch & Lomb research, simplifies your prescribing problem. Your patients receive specific "EXTRAS"—and you receive protected extra income so essential these days with increased living and practicing costs.



PANOPTIK BIFOCAL "EXTRAS"

1. **Natural Vision through neutral absorption** – the only bifocal of its type in Soft-Lite. Unaltered color values. Non-habit-forming
2. **Natural Vision with minimized jump** – the only bifocal of its type with optical centers placed to eliminate zone of confusion
3. **Natural Vision with round corner segments** – the Panoptik-shape reading field is the only one of its type and is instantly identifiable
4. **Natural Vision with greater reading range** – Bausch & Lomb special glass gives greater depth of focus, helping tense presbyopes to relax

PANOPTIK TRIFOCAL "EXTRAS"

1. **Natural Vision with plus performance** – patients requiring trifocals enjoy maximum comfort because of Panoptik's exclusive construction
2. **Natural Vision within all three fields** – the eye moves naturally from distance to intermediate to near point with Panoptik-type segments
3. **Natural Vision without color aberration** – Baryta glass segments by Bausch & Lomb eliminate annoying color fringes many presbyopes dislike
4. **Natural Vision with patient protection** – only Panoptik looks like Panoptik and only Soft-Lite Panoptik does not turn dark in Comparator test

Presbyopes are often sensitive to excess light. They are usually most appreciative of anything that adds to their comfort. The added absorption of Soft-Lite for regular wear is a valuable component of the prescription in these cases. Soft-Lite is the only absorptive glass that does not turn dark in the Comparator, proving its value as a neutral filter. Specify genuine Soft-Lite, available through your friendly Soft-Lite supply house.

Soft-Lite Lenses

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